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Renewable energy and economic growth hypothesis: Evidence from N-11 countries

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ABSTRACT

In the recent years, the trend of environmental sustainability is rapidly increasing by adopting renewable energy resources. However, the main concern is that whether renewable energy consumption contributes to economic growth. To investigate the issue, this study analyzes renewable energy led economic growth hypothesis in the Next-11 economies over the period 1990–2020. Also, this study aims to examine the influence of industry value added, gross national expenditure, and trade openness on economic growth of these economies. Along with the second-generation panel unit root test, this study employed the non-parametric panel data approach, i.e., quantile method of moments regression. The estimated results reveal the slopes coefficients are heterogeneous and cross-sectional dependency is present in the panel. The non-parametric approach reveals that validity of renewable energy led growth hypothesis. Also, the industry value added, gross national expenditure, and trade openness are found positively affecting economic growth of these economies. The panel causality test gives indication of the two way causal association between the variables. Based on the obtained results, policy implications are also provided for governors and researchers.

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1. Introduction

The energy-led economic growth nexus has riveted innumerable scholars and has become an area of exploration for a sustainable environment and development for environmentalists and academicians over the past decades (Wang et al., 2022). The global projections for fossil fuel depletion have raised the greener energy consumption quest around the world. Energy represents partial industrial production and determinant of growth. At present renewable energy is considered an essential factor in the process of sustainable environmental and economic development (Asghar, 2008). It is known that conventional energy comes from limited sources and provides an adequate amount of energy. However, the negative impacts of traditional energy

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sources are far worse than the positive effects (Zhao et al., 2022b). The rising environmental hazards and mounting carbon and greenhouse emissions due to non-renewable energy sources have forced the world to move towards renewable energy consumption (Qudrat-Ullah & Nevo, 2021; Xu et al., 2022). The population surge has also led to an increasing energy demand around the world. Several studies suggested that the consumption of renewable energy has a positive correlation with economic growth. The increase in renewable energy usage enhances the overall welfare of the people beyond the gross domestic product of the country. It creates new jobs and business opportunities for the general public and entrepreneurs. Researchers confirmed that renewable energy lifts economic development besides economic growth and reduces carbon emissions (Abbasi et al., 2020; Tu et al., 2022; Zhao et al., 2022a). In consonance with the International Renewable Energy Agency, renewable energy consumption will increase the global Gross domestic product to 1.1%, enhance human welfare internationally by almost 3.7%, and a progression in employment opportunities by 2030 (IRENA, 2016). It supplies two-thirds of the international energy demand and plays a momentous role in limiting carbon emissions and climate change (Gielen et al., 2019).

There is an extended debate extant in the current literature about energy consumption and its impact on economic growth. The empirical literature is grouped on negative and positive influences. However, the conclusions are still indecisive. Studies like (Bouyghrissi et al., 2021; Kasperowicz et al., 2020; Mohsin et al., 2021) demonstrated a positive and significant relationship between renewable energy and economic growth and established the energy led economic growth hypothesis. The growth hypothesis positions that energy has a positive indispensable role in the expansion of an economy. Despite the fact, in some countries, it has negative or mixed fallouts depending on the economy and income as a whole. For instance, in Italy and Turkey, there exists a negative association between economic growth and renewable energy consumption (Brady & Magazzino, 2018; Ocal & Aslan, 2013; Zhao et al., 2022c). Likewise, Alper and Oguz (2016), Chen et al. (2020), and Okumus et al. (2021) scrutinized the assorted findings depending on the income size, economic development, and threshold levels. Such inconsistent evidences motivates this study to empirical explore the association between the renewable energy consumption and economic growth. Due to the fact that contradictory evidence could lead to destructive policies construction and implementation, this research manages to entice the scholarly interest towards this expanding issue of the current times.

Trade openness and growth of the economy has shown ambiguous relationship in the literature. Quite a few authors depicted a negative association that a low level of financial development in the country leads to a negative impression of trade openness on economic growth. Keho (2017) and Elfaki et al. (2021) described an inverse connotation of trade openness and growth. While some innovative studies found positive associations depending on the geographical location, prevailing development level, and many other relevant factors like macroeconomic stability and native institutions. Economic growth also is contingent on whether it is export-led or import-led depending on the economic condition. Recently, number of studies have established a positive relationship between the aforementioned variables (see for instance Siregar &

Widjanarko, 2022; Banday et al., 2021; Balsalobre-Lorente & Leitão, 2020; Chen et al., 2022). Likewise, the industry value-added has shown positive and negative associations. However, most studies depicted a positive relationship and stated that industry value added is a substantial contributor to the economic growth of a country (Abbasi et al., 2021) & (Rahim et al., 2021). The industry value-added is the private industry that contributes to the GDP of the economy by exciting development and progress of other sectors. Following the backdrop, this study observed that both the industry value added and trade openness could play a positive or negative role in the economic progress of the region. However, due to the presence of inconsistent empirical evidences, the newly developed economies such as the Next Eleven economies could have a detrimental policies regarding the economic growth. Therefore, it is the need of the time to analyze the true impact of these factors on economic growth of such emerging economies.

Our study's objective is to present non-parametric estimates on Renewable Energy led Economic Growth nexus in the next 11 economies. N-11 countries are grouped as developing economies that are expected to exhibit vigorous economic performance in the future. To assist the growth hypothesis in these economies, the paper tends to include renewable energy consumption and control variables like IVA (Industry Value Added), GNE (Gross National Expenditures), TO (Exports and Imports/GDP) trade openness, and GDP constant for economic growth unlike (Chang & Fang, 2022). They were futile in the sustenance of the growth hypothesis in the context of the next 11 economies. Therefore, we accomplish objectives in subsequent ways. In order to provide non-parametric estimates, we employ a novel long-run estimator, Method of Moments Quantile regressions for estimating energy-led growth hypothesis. The efficacy of utilizing this approach lies in, it makes available the information about the regressor's effects on the entire distribution. Second, we employ trade openness and industry value-added and government expenditure alongside that has received little to no attention previously in sustainable energy research. The novelty of the examination is based on analyzation of the growth hypothesis employing a modern approach in the next 11 countries. The findings may assist in shaping renewable energy policies in the milieu of economic growth.

2. Literature review

The following sub-sections elaborate on the empirical studies related to the research. Prior to the relevant literature, it is extensively evident that the increased level of pollution is positively correlated to the increased economic growth. However, it is non-renewable energy consumption, globalization, which is regarded as a driver of increased carbon emissions (Sharif et al., 2019, 2020b; Suki et al., 2020) and is also harmful for human health (Khan et al., 2019; Wei et al., 2022). Whereas it is renewable energy, renewable's investment, fiscal decentralization, financial inclusion, policy instruments regarding environment, financial development, environmental research and development, exports, reduced composite risk, eco-innovation, environmental innovation, a few to mention, which the scholars suggested to be appropriate in terms of environmental recovery without sacrificing economic growth (Cai et al., 2022;

Godil et al., 2021; Jiang et al., 2022; Khan et al., 2020a, 2020b, 2020c, 2021; Luan et al., 2022; Qin et al., 2021; Shahzad et al., 2021; Sharif et al., 2020a). Where most of these studies claimed renewable energy a promising factor of environmental sustainability. Therefore, it is essential to review the relevant literature pertaining to the association of renewables and economic growth.

2.1. What is renewable energy led economic growth hypothesis?

In agreement with Bercu et al. (2019) energy and its consumption has a significant impact on the development of a sustainable economy. Several amount studies for different countries confirmed the energy-led growth hypothesis i.e., renewable energy is the driver of economic growth (Singh et al., 2019). The growth hypothesis states energy plays a positive essential role in the development of an economy and supports the uni-directional causality between renewable energy consumption and economic growth in the long run.

2.2. Economic growth and renewable energy nexus

The existing literature has discussed the economic growth and renewable energy nexus debate in multiple countries. the literature on economic growth and energy is recurrent. Chang and Fang (2022) examined the presence of the said hypothesis in BRICS economies. They applied Methods of moments Quantile regressions and panel estimations from the year 1995 to the year 2019. The empirical results confirmed the growth hypothesis in BRICS countries. Mohsin et al. (2021) found bi-directional causality in 25 Asian countries from 2000 to the year 2016. The findings portrayed that there is a positive association between renewable energy usage and economic growth. They also analyzed the rise in renewable energy usage decreases the harmful carbon dioxide emissions. Bouyghrissi et al. (2021) examined the renewable energy association with economic growth in Morrocco from the period 1990 to 2014. The empirical findings were consistent with the prevailing literature that it has a positive impact on economic sustainable development because of renewable energy consumption. Kassim and Isik (2020) reviewed a summary of 24 research papers on energy and growth nexus. Among them, the mainstream papers confirm the significant association between energy and economic growth. The consumption of energy enhances the growth of the economy. However, the causal association is indecisive. A novel study based on 29 European Union economies described a positive and noteworthy long-run influence between renewable energy consumption and economic growth. The study employed cointegration tests, OLS, and dynamic OLS estimation approaches to analyze the relationship. The discoveries suggested that promoting renewable energy usage enhances economic growth and reduces greenhouse gas emissions in a country (Kasperowicz et al., 2020). Emir and Bekun (2019) affirmed the growth hypothesis and energy-led growth nexus in Romania. The findings suggested uni-directional causality from renewable energy towards the growth of the economy from 1990 to 2014. Koçak and Şarkgüneşi (2017) employed panel cointegration techniques and causality analysis from 1990 to 2012 in Balkan countries and nine Black

Sea nations. The authors found bi-directional causality amid economic growth and consumption of renewable energy in the long run depicting an encouraging substantial influence of energy consumption on the growth of the economy. Lin and Moubarak (2014) studied the energy-led growth nexus in China from 1977 to 2010 employing ARDL and cointegration approaches. The study was consistent with the existing literature that renewable energy and economic growth have bi-directional causality and renewable energy helps in the improvement of the economic growth in the country.

Anyhow some studies have shown controversial findings on the energy-led growth nexus. Namahoro et al. (2021) examined the renewable energy and economic growth nexus in a sample of 75 low-income, middle-income, and upper-income countries from the period 1980 to 2016. They applied recent CS-DL and CCEMG novel techniques and found mixed impacts across the income regions/groups. While overall there is a significant and positive association at the global level. Okumus et al. (2021) investigated the influence of renewable energy (REN) and non-renewable energy (non-REN) consumption on the economic growth in G7 economies from 1980 to 2016 employing bootstrap Granger causality analysis. The resultant coefficients are positive and statistically noteworthy for both REN consumption and non-REN consumption. The empirical findings depicted that the growth hypothesis is only valid for renewable energy consumption on economic growth in Canada, the United States, and Italy. While neutrality exists in renewable energy consumption in France, the United Kingdom, and Japan. Additionally, Germany supports the feedback hypothesis for renewable energy consumption and economic growth. Chen et al. (2020) scrutinized the casual association of renewable energy and economic growth in 103 world countries from the year 1995 to 2015. The developing and non-OECD economies depicted a positive influence of renewable energy on economic growth when they outdo a certain level of threshold. If the economies utilize renewable energy below that ceratin threshold level then the impact is negative. Whereas the OECD economies showed a positive association of renewable energy and economic growth nexus and the developed economies showed no significant response. Ocal and Aslan (2013) investigated the causality nexus in Turkey from 1990 to the year 2010 employing ARDL and Toda-Yamamoto (causality) approaches. The results supported the conservation hypothesis and there was a negative association between economic growth and renewable energy consumption. Whereas the causality tests indicated uni-directional causality between the two above-mentioned variables i.e., from economic growth towards renewable energy consumption. The findings suggest that there is a minimal role of renewable energy in the case of the Turkish economy.

2.3. Association between economic growth, renewable energy consumption, industry value-added, and trade openness

Li et al. (2021) examined the positive and significant impact of renewable energy consumption sources on economic growth in SAARC economies. (Kasperowicz et al., 2020); (Kassim & Isik, 2020) and (Koçak & Şarkgüneşi, 2017) also observed a positive association between economic growth and renewable energy. While some demonstrated mixed results (e.g. Chen et al., 2020; Okumus et al., 2021).

The industry value-added has a negative long-run influence on the economy (Phiri, 2021). Rahim et al. (2021) found a significant positive association with economic growth at a 1 percent level of significance. They also suggested that if there is positive economic growth then the other variables like trade openness, industry value-added, financial development, and technical innovation move side by side. Ali et al. (2016) also found a positive association of industrial value-added on economic growth. The authors recommended that the country promotes exports and enhance import substitution products to strengthen sustainable development in Bangladesh.

Elfaki et al. (2021) in the case of Indonesia from 1984 to 2018 demonstrated the negative association of trade openness and economic growth. Belloumi and Alshehry (2020) evaluated the influence of trade openness on sustainable growth in the case of Saudi Arabia. The empirical results demonstrated that when trade openness is proxied to exports over the Gross domestic product (economic growth), it depicts a negative association. While when it is proxied to imports it shows a positive association with the Gross domestic product (economic growth). Banday et al. (2021) examined the positive association of trade openness with the growth of the economy (long term). The empirical findings depicted long-run bi-directional causality between trade openness and foreign direct investment and foreign direct investment towards economic growth. Balsalobre-Lorente and Leitão (2020) analyzed the influence of trade openness and renewable energy use and carbon dioxide emissions on economic growth from the year 1995 to 2014 in European Union 28 countries applying FMOLS and DOLS econometric techniques. The empirical findings suggest that trade openness and renewable energy usage encourages economic growth in the country. Phiri (2021) scrutinized the empirical impact of trade openness and economic growth in Zambia from the period 1980 to 2019. The findings demonstrated the positive influence of trade openness in the economy. They suggested that trade openness, inflation, terms of trade, and school enrolment accompaniment each other which have a positive effect on the growth of the economy. They also found uni-directional causality from trade openness to the growth of the economy.

2.4. Research gap

After a thorough review of the available literature, this study observed that the empirical evidence provides contradictory arguments regarding nexus of economic growth and renewable energy consumption, which could lead to destructive policies. Also, the literature is observed covering limited time periods along with the traditional econometric approaches to explore the nexus between the said variables. Also, this study observed no empirical study covering the Next-11 region as these economies are showing great progress in terms of economic growth and renewables consumption, which is a wide gap in the scientific research. Therefore, this study tried to fill this gap by utilizing advance and appropriate econometric approaches for achieving the evidence more comprehensively.

3. Methodology

3.1. Data and variable specification

In order to test the energy-led economic growth hypothesis, this study considers economic growth of the selected panel economies captured via gross domestic product (GDP). Since the GDP demonstrates the economy's health and accounted for aggregate investment, consumption, and government expenditure. Also, the literature as mentioned considered GDP as an appropriate representative of economic growth. Hence, the GDP could be used as a dependent variable for comprehensive analysis. On the other hand, this study used renewable energy consumption (REC) as a primary independent variable to investigate the energy-led economic growth hypothesis. The reason for selection of renewable energy is that the recent trend in the environmental protection is the adoption of renewable energy resources to attain maximum energy and accomplish environmental and economic sustainability. Besides, three variables, i.e., industry value added (IVA), gross national expenditure (GNE), and trade openness (TO) are taken as controlled variables. Data for these variables are extracted for the Next-11 economies, including Vietnam, Bangladesh, South Korea, Egypt, Indonesia, Turkey, Pakistan, Iran, Mexico, Nigeria, and Philippines and covering the period from 1990 to 2020. The variables' specification long with the data sources are provided in Table 1.

Following the study of Chang and Fang (2022), this study constructed the following general model:

$$GDP_{it} = f(REC_{it}, IVA_{it}, GNE_{it}, TO_{it})$$

From the above equation, it is noted that REC, IVA, GNE, and TO combinedly is the function of GDP. In order the empirically examine the model, tit could be transformed into regression form, expressed as follows:

Table 1. Variables specification and data sources.

Variables	Specification	Data Source
GDP	Gross domestic product (GDP) is the sum of the market valuations of all completed products and services generated inside the boundaries of a state during a certain time period and measured in constant 2015 US$	
REC	The ratio of gross inland energy consumption from renewable sources to total inland energy usage (primary) determined for a calendar year and measured as a % of total final energy consumption.	
IVA	The contributions of a commercial sector or government sector to the total Gross Domestic Product and measured in constant 2015 US$.	https://databank.worldbank.org/source/world-development-indicators
GNE	The total of final consumption expenditures on goods and services by households, gross capital formation, and general government, and measured in constant 2015 US$.	
TO	Exports plus imports as a percentage of GDP and is a measure of technological innovation import.	

Source: calculated by the authors.

$$GDP_{it} = \alpha_1 + \beta_1 REC_{it} + \beta_2 IVA_{it} + \beta_3 GNE_{it} + \beta_4 TO_{it} + \varepsilon_{it} \tag{1}$$

From the above equation, α and $\beta' s$ are the intercept and slopes, respectively. Whereas the 'i' and 't' in the subscript represents cross-sections and time period, which is 1990–2020 in this case study. Moreover, ε demonstrates the random error of the model.

3.2. Estimation strategy

This study uses descriptive statistics to represent the data summarization prior to doing empirical estimation. Mean, median, and range estimates are evaluated in this regard. Additionally, we forecast the standard deviation, illustrating the distance between each observation and the value of the mean, as well as the volatility of a variable. It uses two key procedures to determine data normality: Kurtosis and Skewness. However, the broader scale of data normality is also used to describe the data distribution. Specifically, we employed the Jarque and Bera (1987) normality test in this case, which is as follows:

$$JB = \frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right), \tag{2}$$

From the equation above, the number of observations is denoted by N, the skewness is denoted by S, and the excess Kurtosis is expressed by K. Because this test evaluates both skewness and excess Kurtosis simultaneously, it is more effective than examining them individually. The proposition of a Jarque-Bera test specifies that both projections (i.e., skewness and excess Kurtosis) must be zero, hence showing the data is normally distributed. The null hypothesis, on the other hand, maybe invalid if the expected results are significant at any specified level.

Once the normality estimates are obtained, this study analyses the panel properties, namely: the slope coefficient heterogeneity (SCH) and cross-section dependency (CD). During and after the industrial revolution, globalization and the exchange of goods and services (trade) between nations accelerated, resulting in some economies specializing in certain commodities and services even as others diversified. Specialization trend, some economies rely on others for various economic, environmental technical and financial gains. This brings up the issue of slope homogeneity, a fundamental issue in an econometric study. Estimating panel data while considering slope homogeneity could be inefficient and deceiving (Breitung, 2005). This study addresses the issue by using the Pesaran and Yamagata (2008) SCH approach. This test is practical because it produces approximate values for both SCH and the adjusted SCH (ASCH), which are denoted by the following:

$$\hat{\Delta}_{SCH} = \sqrt{N(2k)^{-1}}(N^{-1}\acute{S} \; - \mathrm{K}), \tag{3}$$

$$\hat{\Delta}_{ASCH} = \sqrt{N}\sqrt{\frac{T+1}{2K(T-K-1)}}(N^{-1}\acute{S} \ -2K), \tag{4}$$

Where $\hat{\Delta}_{SCH}$ refers to the slope coefficient homogeneity as defined in Eq. (3) and $\hat{\Delta}_{ASCH}$ indicates the adjusted SCH as defined in Eq (4). If the calculated results are statistically significant, the null hypothesis that slopes homogeneity may be denied.

This signifies that disregarding panel considerations like cross-sectional dependency may result in contradictory empirical results (Campello et al., 2019). As a result, we use the Pesaran (2021) CD test to determine if the N-11 economies exhibit cross-sectional dependence properties. The standard formulation of cross-dependence is as follows:

$$CD_{Test} = \frac{\sqrt{2T}}{[N\ (N-1)]^{1/2}} \sum_{i=1}^{N-1} \sum_{k=1+i}^{N} T_{ik}, \tag{5}$$

The null premise of this test establishes that cross-sections are independent throughout the panel.

With the existence of cross-sectional dependency and heterogeneous slope coefficients, this study employed the Pesaran (2007) cross-sectionally augmented IPS test (CIPS). Pesaran (2006) initially introduced factor modeling to accommodate the cross-sectional dependency. Cross-sectional averages are recognized as unexplained factors in this methodology. Pesaran (2007) expands the Augmented Dickey-Fuller regression using the mean and first difference of lagged cross-sections. Even if the panel is unbalanced ($N > T$, or $T > N$), this strategy is more efficient in alleviating cross-section dependence. The cross-sectional ADF regression model is as follows:

$$\Delta y_{i,t} = \theta_i + \beta_i^* y_{i,t-1} + \ d_0 \overline{y}_{t-1} + d_1 \Delta \overline{y}_t + \ \varepsilon_{it}, \tag{6}$$

Where $\overline{y}_t$ is the mean of N observations depicted in Eq. (6). By adding the first differenced lags of $\overline{y}_t$ and y_{it}, a new edition of Eq. (6) may be utilized to account for serial correlation:

$$\Delta y_{it} = \theta_i + \beta_i^* y_{i,t-1} + d_0 \overline{y}_{t-1} + \sum_{j=0}^{n} d_{j+1} \Delta \overline{y}_{t-j} + \sum_{k=1}^{n} c_k \Delta y_{i,t-k} + \ \varepsilon_{it}, \tag{7}$$

Thus, the N-11 panel may calculate the Pesaran (2007) CIPS that use the average t-statistics for every unique cross-section (CADFi). The formula for determining CIPS is as follows:

$$CIPS = \ N^{-1} \sum_{i=1}^{N} CADF_i, \tag{8}$$

If the statistical results are non-significant, Pesaran's (2007) CIPS test assumes the presence of a unit root as a null hypothesis.

Koenker and Bassett, (1978) pioneered panel quantile regression, which uses explanatory parameter values to estimate dependent variance as well as conditional mean. Quantile regression produces efficient estimates when the dataset has irregular distributions. As a result of the data's non-normal distribution, this research employed Machado and Silva (2019) novel Method of Moments Quantile Regression (MMQR). This unique approach examines the distributional as well as heterogeneous characteristics of quantile numbers (Sarkodie & Strezov, 2019). A simple expression can be used to approximate the conditional quantile location-scale $Q_y(\tau|R)$ variants:

$$Y_{it} = \theta_i + \vartheta R_{it} + \left(\delta_i + \rho \acute{Z}_{it}\right)\mu_{it}, \tag{9}$$

Where $p\left(\delta_i + \rho.\acute{Z}_{it} > 0\right) = 1$. Whereas, ϑ, δ, and ρ are the estimated parameters. The subscript (i) reflects the fixed effect described by θ_i and δ_i where $i = 1,2,\ldots,n$, and Z reflects the k-vector of standard elements in R, which exhibits a particular change with component $\mathbb{l}$, expressed as follows:

$$Z_{\mathbb{l}} = Z_{\mathbb{l}}(R),\ \ \mathbb{l} = 1,\ 2,\ \ldots,\ k, \tag{10}$$

This contributes to the stabilization of elements and inhibits external behavior. Hence, Eqs. (1) may take on the following specific form:

$$Q_y(\tau|R_{it}) = (\theta_i + \delta_i q(\tau)) + \vartheta R_{it} + \rho \acute{Z}_{it} q(\tau), \tag{11}$$

Where Eq. (11) shows that R_{it} is the vector of the response variable, which includes *REC, IVA, GNE,* and *TO*. For the empirical study, all of the variables described above are transformed into natural logarithms. The quantile distribution of the dependent variable (in this case, Y_{it} and captured GDP) is conditioned on the location of the explanatory variables and R_{it}, as illustrated in the equation. The scalar coefficient $-\theta_i(\tau) \equiv \theta_i + \delta_i\ q(\tau)$ indicates the fixed impact of t quantiles for i. Individual impact, on the other hand, does not affect the intercept. Due to the time-invariance of the parameters, diverse effects are expected to fluctuate. Finally, $q(\tau)$ signifies the quantiles' $\tau - th$ sample, of which this study assesses four, such as the 25th, then 50th, then 75th, and the 90th. The quantile equation used in this study is as follows:

$$min_q \sum\nolimits_i \sum\nolimits_t \gamma_\tau \left(R_{it} - \left(\delta_i + \rho \acute{Z}_{it}\right).\ q\right), \tag{12}$$

Where $\gamma_\tau(A) = (\tau - 1)AI\{A \leq 0\}\ + TAI\{A > 0\}$, indicates the verify function.

Nonetheless, the MMQR approach provides the estimated result for every regressor at a specific location and scale, but not for their causal link. To establish causality, this study used Dumitrescu and Hurlin (2012) Granger panel causality heterogeneity test. This method seems to be more effective and robust in correcting the panel imbalance ($T \neq N$). Additionally, it handles the variability of panel data and cross-sectional dependence (Banday & Aneja, 2020).

4. Results and discussion

4.1. Results interpretation

This section of the paper provides estimated results via numerous panel methods. First, the section starts with the summary of the variables statistics used in the study called descriptive stats, and the normality distribution of the variables are checked in Table 2. Second, the slope heterogeneity is represented in Table 3. Third, Table 4 presents the cross-sectional dependence of the variables, and Table 5 shows the outcomes of unit root testing. Table 6 displays the Method of Moments Quantile Regressions results with the graphical representation of Quantiles afterward. Last, Table 7 shows the causality results of the Dumitrescu-Hurlin Panel Causality test.

Table 2 displays the expressive statistics of the variables used in the study. The average values of the variables are close to their median values denoting the balancing point of the data. The volatility is represented by the standard deviation values and how the information is spread around its mean. In agreement with Byrne (2013) the skewness ranges from −2 to +2 while the values of Kurosis come in between −7 to +7. The statistical values of skewness and Kurtosis depict the data as symmetrical and normally skewed with normal distribution. Additionally, the Jarque-Bera test also affirms the normal distribution. The probability values of all the variables further approve the significance of the information is proportional and symmetrical.

Slope heterogeneity examines the variation of the variables systematically before moving towards the cross-sectional dependence. It is also applied to measure the cross-sectional heterogeneity in econometric analysis that is generally nonexistent in traditional tests (Khan et al., 2020b). Table 3 of the paper represents the outcomes of slope heterogeneity in the model. The statistical values of the model are substantial indicating the rejection of the null hypothesis at a 1% level of significance. The findings depict the presence of correlation among the econometric research models. This primes towards the cross-sectional dependence of the variables.

Table 2. Descriptive statistics and normality check.

	GDP	REC	IVA	GNE	TO
Mean	11.47679	1.196004	11.37112	11.48075	11.70743
Median	11.47722	1.448570	11.37501	11.47334	11.74016
Maximum	12.21427	1.948165	12.02514	12.19126	12.80323
Minimum	10.56636	−0.357140	10.60202	10.68293	10.08623
Std. Dev.	0.365443	0.647826	0.341628	0.358035	0.529208
Skewness	−0.033495	−0.913301	−0.020207	0.000770	−0.317493
Kurtosis	2.367933	2.638812	2.267537	2.285484	3.196525
Jarque-Bera	5.740122	49.25928	7.646017	7.253849	6.277666
Probability	0.056695	0.000000	0.021862	0.026598	0.043333

Source: calculated by the authors.

Table 3. Slope heterogeneity.

Slope Heterogeneity Test	Statistics
Model-1	
$\sim\Delta$	24.530***
$\sim\Delta^{Adjusted}$	27.315***

Note: Significance level is denoted by *** for 1%, ** for 5% and * for 10%.
Source: calculated by the authors.

Table 4. Cross-section dependence.

Cross-Section Dependence		
GDP		REC
40.411***		18.876***
IVA		GNE
33.606***		32.054***
	TO	
	34.071***	

Note: Significance level is denoted by *** for 1%, ** for 5% and * for 10%.
Source: calculated by the authors.

Table 5. Unit root testing (Pesaran, 2007).

	Intercept and Trend	
Variables	**I**(0)	**I**(1)
GDP	−1.715	−3.844***
REC	−2.653	−5.381***
IVA	−2.322	−4.572***
GNE	−2.215	−4.273***
TO	−2.103	−5.073***

Note: Significance level is denoted by *** for 1%, ** for 5% and * for 10%. I(0) is for level, and I(1) is for the first.
Source: calculated by the authors.

Table 6. Estimates of quantile regression–MMQR.

			Quantiles			
Dep. Var.: GDP	Location	Scale	$Q_{0.25}$	$Q_{0.50}$	$Q_{0.75}$	$Q_{0.90}$
REC	0.038***	0.038***	0.015	0.038***	0.0789***	0.102***
	[0.010]	[0.007]	[0.010]	[0.010]	[0.013]	[0.016]
IVA	0.362***	0.099***	0.302***	0.362***	0.468***	0.529***
	[0.053]	[0.037]	[0.055]	[0.052]	[0.066]	[0.081]
GNE	0.481***	−0.090**	0.536***	0.481***	0.384***	0.328***
	[0.053]	[0.037]	[0.056]	[0.052]	[0.067]	[0.082]
TO	0.103***	−0.001	0.103***	0.103***	0.101***	0.101***
	[0.019]	[0.013]	[0.021]	[0.019]	[0.024]	[0.030]
Constant	0.736***	−0.025	0.751***	0.735***	0.709***	0.694**
	[0.177]	[0.123]	[0.190]	[0.177]	[0.233]	[0.276]

Note: The dependent variable used here is GDP. Significance level is denoted by ***, ** and * for 1%, 5% and 10%. The standard error is provided in the brackets.
Source: calculated by the authors.

Table 7. Dumitrescu-Hurlin panel causality.

$\mathbf{H_0}$	$\mathbf{Wald_{Stats}}$	$\bar{\mathbf{Z}}_{\mathbf{stats}}$	**p − value**
REC $\nrightarrow$ GDP	4.689***	2.70384	0.0000
GDP $\nrightarrow$ REC	7.434***	7.28881	3.E-13
IVA $\nrightarrow$ GDP	3.502*	1.83255	0.0669
GDP $\nrightarrow$ IVA	7.020***	6.71390	2.E-11
GNE $\nrightarrow$ GDP	4.207***	2.81100	0.0049
GDP $\nrightarrow$ GNE	8.302***	8.49363	0.0000
TO $\nrightarrow$ GDP	4.321***	3.19451	0.0008
GDP $\nrightarrow$ TO	7.056***	6.76432	1.E-11

Note: Significance level is denoted by *** for 1%, ** for 5% and * for 10%.
Source: calculated by the authors.

Applying panel data analysis is often imperiled to cross-sectional dependence. Every component affects each unit in different ways. Table 4 discloses the outcomes of the cross-sectional dependence of the research variables. The statistical values of each variable confirm the presence of dependence cross-sectionally rejecting the null hypothesis. All variables are substantial at a 1% level of significance implying the Gross Domestic Product (economic growth) is not only dependent on renewable energy consumption, trade openness, Gross national expenditure, and industry value-added but also these variables are cross-sectionally dependent on each other as well. These findings lead to estimating the stationarity of the variables at the level.

Usually, Pesaran's (2007) unit root tests are applied for panel cross-sectional data estimation. Pesaran (2007) provides reliable cross-sectional results employing Augmented Dickey fuller statistics for cross-sectionality. These tests govern the stationarity of the research variables. It is considered as a pre-test before cointegration or regression analysis. (Zivot & Wang, 2006) conversed that presence of root is equal to one or unity. The cross-sectional unit-roots analysis is preferred over conventional unit root tests because they give spurious results and become unreliable, due to the existence of dependence (cross-sectional). Table 5 represents the results of the Pesaran unit root test. The variable renewable energy consumption (REC), industry value added (IVA), Gross national expenditure (GNE), and Trade openness (TO) is stationary at the level I(1) with higher negative coefficient values. The indication of negative values of unit root confirms the presence of unit root thereby rejecting the null hypothesis. The variables are statistically significant at the first difference at a 1 percent level of significance. The results confirmed the presence of cross-sectional dependence in the model variables. Certainly, when cross-sectional dependence occurs that requires a standard regression estimation technique and ignoring it led to under-rejection of the null hypothesis.

For distributional heterogeneity of the study countries across the panel, we applied a novel econometric technique of Quantile regression via Method of Moments developed by (Machado & Silva, 2019). It is outlier resistant regressions through the method of moments. The probability values of the respective variables are statistically significant with 99 and 95 percent confidence intervals at all four quantiles except the renewable energy consumption at $Q_{0.25}$. the results depict that renewable energy-led economic growth is significant in the model for the Next Eleven nations across all quantiles. The results based on location-scale parameters also confirm the significance of renewable energy consumption, industry value-added, GNE, and trade openness on the growth of the economy. The coefficients are positive and statistically significant depicting that all the variables influence the growth of the region. The N-11 countries must consider renewable energy consumption, industry value-added (manufacturing included), and international trade to ensure economic growth. The accuracy of the results is denoted by the standard errors shown in the bracket in Table 6 of MMQR. The lower value of standard errors shows the sophisticated precision of the estimation results (Figure 1).

The graphical presentation of Quantiles shows in what way the lower and upper quantiles are outside the ordinary least squares. The graphs show the impact of the independent variables on the economic growth of the panel data countries.

This causality test is an advanced form of the Granger causality test that is utilized for estimating the panel data analysis. There are eight pairs of variables in the model to determine the causality of the variables displayed in Table 7 of the sub-section of

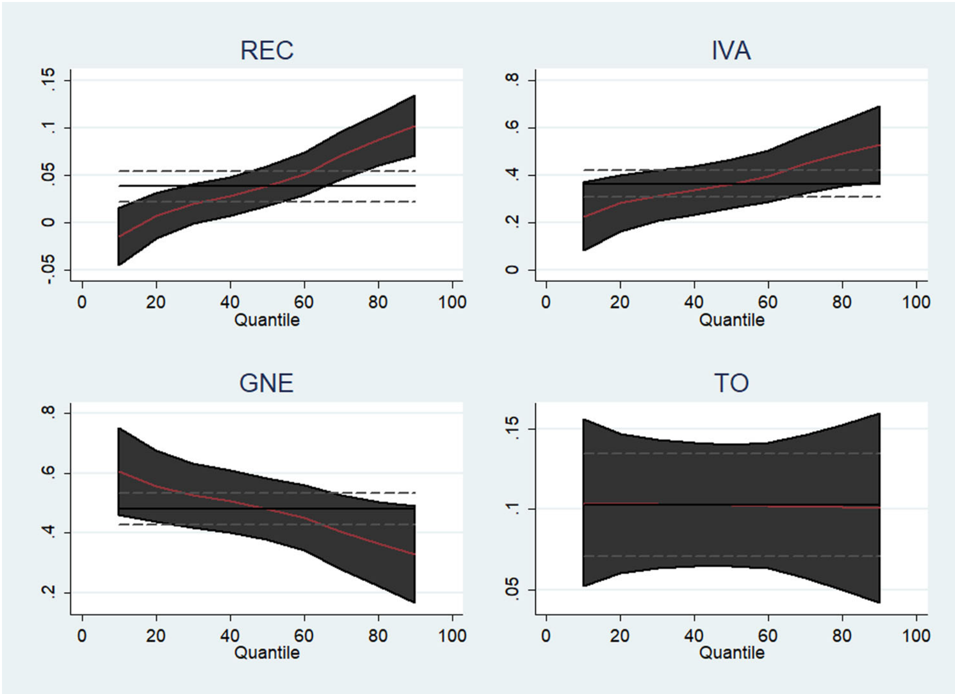

Figure 1. Graphical representation of quantiles for model-1.
Source: drawn by the authors.

the present paper. The overall findings of the tests reveal that there is statistically significant causation among the variables. IVA $\nrightarrow$ GDP is significant at a 0.10 (10%) level of significance while all others REC $\nrightarrow$ GDP, GDP $\nrightarrow$ REC, GDP $\nrightarrow$ IVA, GNE $\nrightarrow$ GDP, GDP $\nrightarrow$ GNE, TO $\nrightarrow$ GDP, and GDP $\nrightarrow$ TO have significant values at a 0.01 (1%) level of significance. This specifies that we will reject the null hypothesis signifying the influence of control variables on the economic growth of the country.

Largely, the results portray the bi-directional Granger causality of the study variables. Renewable energy consumption has a positive and substantial influence on the economic growth of the country. The Dumitrescu-Hurlin Panel Causality revealed the bi-directional causality, reliable with the studies of (Mohsin et al., 2021) & (Koçak & Şarkgüneşi, 2017). The industry value-added assists in the process of economic growth. Increasing the industrial value is beneficial for the economic growth of the economy, in line with the findings of (Rahim et al., 2021) & (Ali et al., 2016). Moreover, the Granger causality (DMPC) outcomes embody the bi-directional causality between the economic growth (GDP) and industry value-added. The gross national spending also demonstrates bi-directional Granger causality among economic growth and growth national expenditure, as exhibited in Table 7 of the study. It is consistent with the findings of (Popescu & Diaconu, 2021). There is an interconnection between the spending of government and economic growth (GDP) and the findings are signifying the state involvement in the process of growth and development. last of all, trade openness has also shown bi-directional causality via the panel causality test with substantial values at 0.01 level of significance. Such empirical results are in line with the empirical results of Balsalobre-Lorente and Leitão (2020), Banday et al. (2021) and Silajdzic and Mehic (2018). Trade openness increases welfare transitions and increases income and growth through trade neutrality or neutral trade orientation of the economy. Thus, the marginal impact of imports and exports on the Gross Domestic Product share has a positive impact on economic growth.

4.2. Discussion

The study explored the growth hypothesis validity in the next 11 economies by employing non-parametric estimation measures. The research is envisioned to enhance the knowledge on the influence of the energy-led growth hypothesis considering the next 11 countries. To accomplish this, first slope heterogeneity and cross-sectional dependence tests are applied after checking the summary statistics of the variables. The cross-sectional dependence test led the process to move toward the unit root test to determine the stationarity of the existing variables. Later, the method of moments Quantile regressions provided significant results validating the influence of renewable energy consumption, industry value-added, gross national expenditures, and trade openness on the enhancement of economic growth. The Dumitrescu-Hurlin Panel Causality analysis further signified the results demonstrating bi-directional causality among all the pair variables verifying the causality analysis of the study. Despite all, our findings are consistent with the prevailing literature (Mohsin et al., 2021); (Rahim et al., 2021); (Popescu & Diaconu, 2021); and (Banday et al., 2021). The hypothesis makes the country's growth and production scalable and flourishes with time. Due to increasing globalization and industrialization, economic activities tend to rise that affect the sustainable environment. The all-inclusive estimates for fossil fuel diminution have elevated renewable expedition everywhere in the world. The increase in renewable energy consumption not only improves the Gross domestic product of the country but also improves the inclusive welfare of the people. It creates new jobs and business opportunities for its citizens and entrepreneurs. The production capacity is also amplified that in return upsurges the economic activity and leads to the augmented national income of the economy. Abbasi et al. (2020) scrutinized that renewable energy kicks economic development above and beyond economic growth, in addition, condenses the detrimental carbon emissions.

5. Conclusion and policy implications

All things considered; the aforementioned sequences of panel techniques demonstrated the connotation of the study variables. The main purpose of the study is to discover the non-parametric evaluations on Renewable Energy led Economic Growth hypothesis in the next 11 countries. The coefficient estimates of the panel regression techniques and Dumitrescu-Hurlin panel causality test validated the growth hypothesis and re-confirmed the interdependence of growth and renewable energy. The discoveries are robust as per the predominant literature, such as (Mohsin et al., 2021); (Rahim et al., 2021); (Popescu & Diaconu, 2021); and (Banday et al., 2021). The verdicts established bi-directional causality of the pair variables. we found that there is a positive and statistically significant influence of energy on the Gross Domestic Product in the N-11 countries. The originality and uniqueness of the study exist in employing the recent modern Method of Moments Quantile Regression approach and utilizing trade openness and industry value-added and government expenditure variables alongside that have received no consideration beforehand in sustainable energy research. Contrasting the findings of (Chang & Fang, 2022), where the authors are unsuccessful in the sustenance of the energy-led growth hypothesis in the context of the next 11 economies but validated in BRICS economies. Therefore, it is recognized that renewable energy consumption plays a substantial role in the growth of the economy besides the control variables. The explanatory variables help in boosting economic growth. It creates employment opportunities and is effective in limiting pollution (greenhouse gas) emissions and climate change.

As per the outcomes of the research paper, it is recommended that renewable energy usage could be a blessing for countries for improving economic growth. Operative policies are required in the efficient management of renewable energy sources. To be more specific, the literature already provided evidence regarding the favorable role of renewable energy on environmental sustainability, while this research explores its positive role on economic growth. In this context, enhancement in the renewable energy related investment could further promote the economic expansion. Industry value-added is playing a substantial role in enhancing economic growth. Industrial development excites and promotes growth by increasing the production activities in manufacturing and other sectors of the economy in the N-11 countries. Therefore, increased industry value added could help the N-11 economies to achieve higher economic growth. The implication of the findings is to increase the renewable shares of energy production, shift from non-renewable to the renewable sector for sustainable environment and development. As per se, a good and efficient form of government proportionally influences economic growth. It is suggested that the governmental institutions expedite the renewable energy transition and enhance international trade among nations that boost growth. Hence, these economies must increase the expenditure for the provision of sustainable energy to the native citizens or efficiently utilize the available expenses for renewable energy consumption sources. The local government could provide subsidies and tax benefits for the industries utilizing renewable energy in order to make these energy sources more attractive and feasible for the people as well as economy as a whole. As a consequence, it will be advantageous for the economy as well as beneficial for the sustainable environment in the long term.

Nonetheless, this research attempted to investigate the contradictory evidence regarding the influence of renewable energy consumption on economic growth, where the empirical results are a substantial contribution to the existing literature. Still this study is limited in terms of lacking in the provision of evidence regarding other environmentally friendly factors such as energy efficiency, and renewable electricity, among others. Besides, this study investigates only the last three decades, which although had important yet insufficient evidence regarding the said nexus. Furthermore, there are various environmental indicators such as foreign direct investment, exports, investment in renewables, research and development investment, that could influence economic growth, yet these variables are out of the scope of this research. Moreover, this study only focused on the long-run coefficients, whereas the short-run estimates could provide more in-depth analysis of the prevailing problem, which is suggested for the future researchers.

For future research, the study findings can be taken into account to examine the hypothesis in N-11 countries and other economies by introducing other relevant analysis factors and determinants like foreign direct investment, public and private institutions, technological innovation, research and development, and the financial stability of the country.

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References

Abbasi, K., Jiao, Z., Shahbaz, M., & Khan, A. (2020). Asymmetric impact of renewable and non-renewable energy on economic growth in Pakistan: New evidence from a nonlinear analysis. *Energy Exploration & Exploitation*, *38*(5), 1946–1967. https://doi.org/10.1177/0144598720946496

Abbasi, K. R., Shahbaz, M., Jiao, Z., & Tufail, M. (2021). How energy consumption, industrial growth, urbanization, and CO2 emissions affect economic growth in Pakistan? A novel dynamic ARDL simulations approach. *Energy*, *221*, 119793. https://doi.org/10.1016/j.energy.2021.119793

Ali, S., Alam, K. J., & Islam, M. S. (2016). Effects of trade openness and industrial value added on economic growth in Bangladesh. *International Journal of Sustainable Development Research*, *2*(2), 6–11.

Alper, A., & Oguz, O. (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews*, *60*, 953–959. https://doi.org/10.1016/j.rser.2016.01.123

Asghar, Z. (2008). Energy-GDP relationship: A causal analysis for the five countries of South Asia. *Applied Econometrics and International Development*, *8*(1), 167–180.

Balsalobre-Lorente, D., & Leitão, N. C. (2020). The role of tourism, trade, renewable energy use and carbon dioxide emissions on economic growth: Evidence of tourism-led growth hypothesis in EU-28. *Environmental Science and Pollution Research International*, *27*(36), 45883–45896. https://doi.org/10.1007/s11356-020-10375-1

Banday, U. J., & Aneja, R. (2020). Renewable and non-renewable energy consumption, economic growth and carbon emission in BRICS: Evidence from bootstrap panel causality. *International Journal of Energy Sector Management*, *14*(1), 248–260. https://doi.org/10.1108/IJESM-02-2019-0007

Banday, U. J., Murugan, S., & Maryam, J. (2021). Foreign direct investment, trade openness and economic growth in BRICS countries: Evidences from panel data. *Transnational Corporations Review*, *13*(2), 211–221. https://doi.org/10.1080/19186444.2020.1851162

Bayer, C., & Hanck, C. (2013). Combining non-cointegration tests. *Journal of Time Series Analysis*, *34*(1), 83–95. https://doi.org/10.1111/j.1467-9892.2012.00814.x
Belloumi, M., & Alshehry, A. (2020). The impact of international trade on sustainable development in Saudi Arabia. *Sustainability*, *12*(13), 5421. https://doi.org/10.3390/su12135421
Bercu, A. M., Paraschiv, G., & Lupu, D. (2019). Investigating the energy–economic growth–governance nexus: Evidence from central and eastern European countries. *Sustainability*, *11*(12), 3355. https://doi.org/10.3390/su11123355
Bouyghrissi, S., Berjaoui, A., & Khanniba, M. (2021). The nexus between renewable energy consumption and economic growth in Morocco. *Environmental Science and Pollution Research International*, *28*(5), 5693–5703. https://doi.org/10.1007/s11356-020-10773-5
Brady, G. L., & Magazzino, C. (2018). The relationship among renewable energy, economic growth, labor and capital formation in Italy. *Rivista DI Studi Sulla Sostenibilita*, *6*(1), 35–48. https://doi.org/10.3280/RISS2018-001005
Breitung, J. (2005). A parametric approach to the estimation of cointegration vectors in panel data. *Econometric Reviews*, *24*(2), 151–173. https://doi.org/10.1081/ETC-200067895
Byrne, B. M. (2013). *Structural equation modeling with Mplus: Basic concepts, applications, and programming*. Routledge.
Cai, X., Wang, W., Rao, A., Rahim, S., & Zhao, X. (2022). Regional sustainable development and spatial effects from the perspective of renewable energy. *Frontiers in Environmental Science*, *10*, 859523. https://doi.org/10.3389/fenvs.2022.859523
Campello, M., Galvao, A. F., & Juhl, T. (2019). Testing for slope heterogeneity bias in panel data models. *Journal of Business & Economic Statistics*, *37*(4), 749–760. https://doi.org/10.1080/07350015.2017.1421545
Chang, C. L., & Fang, M. (2022). Renewable energy-led growth hypothesis: New insights from BRICS and N-11 economies. *Renewable Energy*, *188*, 788–800. https://doi.org/10.1016/j.renene.2022.02.052
Chen, C., Pinar, M., & Stengos, T. (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy Policy*, *139*, 111295. https://doi.org/10.1016/j.enpol.2020.111295
Chen, H., Shi, Y., & Zhao, X. (2022). Investment in renewable energy resources, sustainable financial inclusion and energy efficiency: A case of US economy. *Resources Policy*, *77*, 102680. https://doi.org/10.1016/j.resourpol.2022.102680
Dogan, E. (2016). Analyzing the linkage between renewable and non-renewable energy consumption and economic growth by considering structural break in time-series data. *Renewable Energy*, *99*, 1126–1136. https://doi.org/10.1016/j.renene.2016.07.078
Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modelling*, *29*(4), 1450–1460. https://doi.org/10.1016/j.econmod.2012.02.014
Elfaki, K. E., Handoyo, R. D., & Ibrahim, K. H. (2021). The impact of industrialization, trade openness, financial development, and energy consumption on economic growth in Indonesia. *Economies*, *9*(4), 174. https://doi.org/10.3390/economies9040174
Emir, F., & Bekun, F. V. (2019). Energy intensity, carbon emissions, renewable energy, and economic growth nexus: New insights from Romania. *Energy & Environment*, *30*(3), 427–443. https://doi.org/10.1177/0958305X18793108
Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, *24*, 38–50. https://doi.org/10.1016/j.esr.2019.01.006
Godil, D. I., Yu, Z., Sharif, A., Usman, R., & Khan, S. A. R. (2021). Investigate the role of technology innovation and renewable energy in reducing transport sector CO2 emission in China: A path toward sustainable development. *Sustainable Development*, *29*(4), 694–707. https://doi.org/10.1002/sd.2167
IRENA. (2016). *Renewable energy benefits: Measuring the economics*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Measuring-the-Economics_2016.pdf

Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review / Revue Internationale de Statistique*, *55*(2), 163–172. https://doi.org/10.2307/1403192

Jiang, S., Chishti, M. Z., Rjoub, H., & Rahim, S. (2022). Environmental R&D and trade-adjusted carbon emissions: Evaluating the role of international trade. *Environmental Science and Pollution Research*, https://doi.org/10.1007/s11356-022-20003-9

Kasperowicz, R., Bilan, Y., & Štreimikienė, D. (2020). The renewable energy and economic growth nexus in European countries. *Sustainable Development*, *28*(5), 1086–1093. https://doi.org/10.1002/sd.2060

Kassim, F., & Isik, A. (2020). *Impact of energy consumption on industrial growth in a transition economy: Evidence from Nigeria*. https://mpra.ub.uni-muenchen.de/101757/

Keho, Y. (2017). The impact of trade openness on economic growth: The case of Cote d'Ivoire. *Cogent Economics & Finance*, *5*(1), 1332820. https://doi.org/10.1080/23322039.2017.1332820

Khan, Z., Malik, M. Y., Latif, K., & Jiao, Z. (2020c). Heterogeneous effect of eco-innovation and human capital on renewable & non-renewable energy consumption: Disaggregate analysis for G-7 countries. *Energy*, *209*, 118405. https://doi.org/10.1016/j.energy.2020.118405

Khan, Z., Ali, S., Dong, K., & Li, R. Y. M. (2021). How does fiscal decentralization affect CO2 emissions? The roles of institutions and human capital. *Energy Economics*, *94*, 105060. https://doi.org/10.1016/j.eneco.2020.105060

Khan, Z., Ali, M., Jinyu, L., Shahbaz, M., & Siqun, Y. (2020a). Consumption-based carbon emissions and trade nexus: Evidence from nine oil exporting countries. *Energy Economics*, *89*, 104806. https://doi.org/10.1016/j.eneco.2020.104806

Khan, Z., Ali, S., Umar, M., Kirikkaleli, D., & Jiao, Z. (2020b). Consumption-based carbon emissions and international trade in G7 countries: The role of environmental innovation and renewable energy. *The Science of the Total Environment*, *730*, 138945. https://doi.org/10.1016/j.scitotenv.2020.138945

Khan, Z., Murshed, M., Dong, K., & Yang, S. (2021). The roles of export diversification and composite country risks in carbon emissions abatement: Evidence from the signatories of the Regional Comprehensive Economic Partnership agreement. *Applied Economics*, *53*(41), 4769–4787. https://doi.org/10.1080/00036846.2021.1907289

Khan, S. A. R., Sharif, A., Golpîra, H., & Kumar, A. (2019). A green ideology in Asian emerging economies: From environmental policy and sustainable development. *Sustainable Development*, *27*(6), 1063–1075. https://doi.org/10.1002/sd.1958

Koçak, E., & Şarkgüneşi, A. (2017). The renewable energy and economic growth nexus in Black Sea and Balkan countries. *Energy Policy*, *100*, 51–57. https://doi.org/10.1016/j.enpol.2016.10.007

Koenker, R., & Bassett, G. (1978). Regression quantiles. *Econometrica*, *46*(1), 33–50. https://doi.org/10.2307/1913643

Li, Q., Cherian, J., Shabbir, M. S., Sial, M. S., Li, J., Mester, I., & Badulescu, A. (2021). Exploring the relationship between renewable energy sources and economic growth. The case of SAARC countries. *Energies*, *14*(3), 520. https://doi.org/10.3390/en14030520

Lin, B., & Moubarak, M. (2014). Renewable energy consumption–economic growth nexus for China. *Renewable and Sustainable Energy Reviews*, *40*, 111–117. https://doi.org/10.1016/j.rser.2014.07.128

Luan, S., Hussain, M., Ali, S., & Rahim, S. (2022). China's investment in energy industry to neutralize carbon emissions: Evidence from provincial data. *Environmental Science and Pollution Research International*, *29*(26), 39375–39383. https://doi.org/10.1007/s11356-021-18141-7

Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics*, *213*(1), 145–173. https://doi.org/10.1016/j.jeconom.2019.04.009

Mohsin, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic

growth-environmental nexus from developing Asian economies. *Journal of Environmental Management*, *284*, 111999. https://doi.org/10.1016/j.jenvman.2021.111999
Namahoro, J. P., Nzabanita, J., & Wu, Q. (2021). The impact of total and renewable energy consumption on economic growth in lower and middle-and upper-middle-income groups: Evidence from CS-DL and CCEMG analysis. *Energy*, *237*, 121536. https://doi.org/10.1016/j.energy.2021.121536
Ocal, O., & Aslan, A. (2013). Renewable energy consumption–economic growth nexus in Turkey. *Renewable and Sustainable Energy Reviews*, *28*, 494–499. https://doi.org/10.1016/j.rser.2013.08.036
Okumus, I., Guzel, A. E., & Destek, M. A. (2021). Renewable, non-renewable energy consumption and economic growth nexus in G7: Fresh evidence from CS-ARDL. *Environmental Science and Pollution Research International*, *28*(40), 56595–56605. https://doi.org/10.1007/s11356-021-14618-7
Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, *74*(4), 967–1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x
Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312. https://doi.org/10.1002/jae.951
Pesaran, M. H. (2021). General diagnostic tests for cross-sectional dependence in panels. *Empirical Economics*, *60*(1), 13–50. https://doi.org/10.1007/s00181-020-01875-7
Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50–93. https://doi.org/10.1016/j.jeconom.2007.05.010
Phiri, C. (2021). *Trade openness and economic growth: The Zambian case* [Doctoral dissertation]. Bursa Uludag University.
Popescu, C. C., & Diaconu, L. (2021). Government spending and economic growth: A cointegration analysis on Romania. *Sustainability*, *13*(12), 6575. https://doi.org/10.3390/su13126575
Qin, L., Raheem, S., Murshed, M., Miao, X., Khan, Z., & Kirikkaleli, D. (2021). Does financial inclusion limit carbon dioxide emissions? Analyzing the role of globalization and renewable electricity output. *Sustainable Development*, *29*(6), 1138–1154. https://doi.org/10.1002/sd.2208
Qudrat-Ullah, H., & Nevo, C. M. (2021). The impact of renewable energy consumption and environmental sustainability on economic growth in Africa. *Energy Reports*, *7*, 3877–3886. https://doi.org/10.1016/j.egyr.2021.05.083
Rahim, S., Murshed, M., Umarbeyli, S., Kirikkaleli, D., Ahmad, M., Tufail, M., & Wahab, S. (2021). Do natural resources abundance and human capital development promote economic growth? A study on the resource curse hypothesis in Next Eleven countries. *Resources, Environment and Sustainability*, *4*, 100018. https://doi.org/10.1016/j.resenv.2021.100018
Sarkodie, S. A., & Strezov, V. (2019). A review on environmental Kuznets curve hypothesis using bibliometric and meta-analysis. *The Science of the Total Environment*, *649*, 128–145. https://doi.org/10.1016/j.scitotenv.2018.08.276
Shahzad, U., Radulescu, M., Rahim, S., Isik, C., Yousaf, Z., & Ionescu, S. A. (2021). Do environment-related policy instruments and technologies facilitate renewable energy generation? Exploring the contextual evidence from developed economies. *Energies*, *14*(3), 690. https://doi.org/10.3390/en14030690
Sharif, A., Afshan, S., Chrea, S., Amel, A., & Khan, S. A. R. (2020a). The role of tourism, transportation and globalization in testing environmental Kuznets curve in Malaysia: New insights from quantile ARDL approach. *Environmental Science and Pollution Research International*, *27*(20), 25494–25509. https://doi.org/10.1007/s11356-020-08782-5
Sharif, A., Baris-Tuzemen, O., Uzuner, G., Ozturk, I., & Sinha, A. (2020b). Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. *Sustainable Cities and Society*, *57*, 102138. https://doi.org/10.1016/j.scs.2020.102138

Sharif, A., Raza, S. A., Ozturk, I., & Afshan, S. (2019). The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: A global study with the application of heterogeneous panel estimations. *Renewable Energy*, *133*, 685–691. https://doi.org/10.1016/j.renene.2018.10.052

Silajdzic, S., & Mehic, E. (2018). Trade openness and economic growth: empirical evidence from transition economies. In *Trade and global market* (pp. 2, 9–23). IntechOpen. doi: 10.5772/intechopen.75812

Singh, N., Nyuur, R., & Richmond, B. (2019). Renewable energy development as a driver of economic growth: Evidence from multivariate panel data analysis. *Sustainability*, *11*(8), 2418. https://doi.org/10.3390/su11082418

Siregar, A. P., & Widjanarko, N. P. A. (2022). The impact of trade openness on economic growth: Evidence from agricultural countries. *The Journal of Asian Finance, Economics and Business*, *9*(3), 23–31.

Suki, N. M., Sharif, A., Afshan, S., & Suki, N. M. (2020). Revisiting the Environmental Kuznets Curve in Malaysia: The role of globalization in sustainable environment. *Journal of Cleaner Production*, *264*, 121669. https://doi.org/10.1016/j.jclepro.2020.121669

Tu, Z., Feng, C., & Zhao, X. (2022). Revisiting energy efficiency and energy related CO2 emissions: Evidence from RCEP economies. *Economic Research-Ekonomska Istraživanja*, *35*, 1–21. https://doi.org/10.1080/1331677X.2022.2038651

Wang, C., Elfaki, K. E., Zhao, X., Shang, Y., & Khan, Z. (2022). International trade and consumption-based carbon emissions: Does energy efficiency and financial risk ensure sustainable environment? *Sustainable Development*, 1–11. https://doi.org/10.1002/sd.2320

Wei, J., Rahim, S., & Wang, S. (2022). Role of environmental degradation, institutional quality, and government health expenditures for human health: Evidence from emerging seven countries. *Frontiers in Public Health*, *10*, 870767. https://doi.org/10.3389/fpubh.2022.870767

Xu, Y., Li, S., Zhou, X., Shahzad, U., & Zhao, X. (2022). How environmental regulations affect the development of green finance: Recent evidence from polluting firms in China. *Renewable Energy*, *189*, 917–926. https://doi.org/10.1016/j.renene.2022.03.020

Zhao, X., Ma, X., Shang, Y., Yang, Z., & Shahzad, U. (2022c). Green economic growth and its inherent driving factors in Chinese cities: Based on the Metafrontier-global-SBM super-efficiency DEA model. *Gondwana Research*, *106*, 315–328. https://doi.org/10.1016/j.gr.2022.01.013

Zhao, X., Ramzan, M., Sengupta, T., Deep Sharma, G., Shahzad, U., & Cui, L. (2022b). Impacts of bilateral trade on energy affordability and accessibility across Europe: Does economic globalization reduce energy poverty? *Energy and Buildings*, *262*, 112023. https://doi.org/10.1016/j.enbuild.2022.112023

Zhao, X., Shang, Y., Ma, X., Xia, P., & Shahzad, U. (2022a). Does carbon trading lead to green technology innovation: Recent evidence from Chinese companies in resource-based industries. *IEEE Transactions on Engineering Management*, 1–18. https://doi.org/10.1109/TEM.2022.3186905

Zivot, E., & Wang, J. (2006). Unit root tests. In *Modeling financial time series with S-plus®* (pp. 111–139). New York, NY: Springer.