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Article

The impacts of trade, innovations, urbanization, financial development and CO_2 emission on renewable and non-renewable energy use in India

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Abstract: India has experienced notable advancements in trade liberalization, innovation tactics, urbanization, financial expansion, and sophisticated economic development. Researchers are focusing more on how much energy consumption of both renewable and non-renewable accounts for overall system energy consumption in light of these dynamics. In order to gain an understanding of this important and contentious issue, we aim to examine the impact of trade openness, inventions, urbanization, financial expansion, economic development, and carbon emissions affected the usage of renewable and non-renewable energy (REU and N-REU) in India between 1980 and 2020. We apply the econometric approach involving unit root tests, FE-OLS, D-OLS, and FM-OLS, and a new Quantile Regression approach (QR). The empirical results demonstrate that trade openness, urbanization and CO_2 emissions are statistically significant and negatively linked with renewable energy utilization. In contrast, technological innovations, financial development, and economic development in India have become a source of increase in renewable energy utilization. Technological innovations were considered negatively and statistically significant in connection with non-renewable energy utilization, whereas the trade, urbanization, financial growth, economic growth, and carbon emissions have been established that positively and statistically significant influence non-renewable energy utilization. The empirical results of this study offer some policy recommendations. For instance, as financial markets are the primary drivers of economic growth and the renewable energy sector in India, they should be supported in order to reduce CO_2 emissions.

Keywords: energy consumption; trade openness; technological innovations; financial development; carbon emission; quantile regression

1. Introduction

Since India is the world's greatest energy user, technological advancements, trade openness, urbanization, financial expansion, and economic development are the primary causes of high energy consumption. Currently, the dynamics of renewable energy are giving rise to a number of new concepts, such as technological advancement, economic growth, and trade openness. Relationships between trade openness, energy consumption, and economic growth offer an intriguing field for empirical research (Alam and Murad, 2020; Jahanger et al., 2022). A country's ability to maintain economic growth depends heavily on its energy consumption, which is why demand for it has been rising for decades (Eren et al., 2019). According to World Bank estimates, energy consumption accounted for 71% of the growth in energy between 1971 and 2014, or a 41% increase. Significant amounts of CO_2 are released into the atmosphere as a result of the widespread use of fossil fuels, which contributes to global warming and environmental deterioration. Between 0.4° and 0.8° Celsius of temperature increase occurred in the century before, and over the previous 200 years, CO_2 emissions had increased by 31% (Panwar et al., 2011). CO_2 emissions-based environmental pollution is becoming a bigger hazard to both human health and the survival of many other species. In addition to negative effects on the environment, importing nations may experience energy insecurity as a result of ongoing fossil fuel consumption. Therefore, achieving economic development requires long-term energy conservation programs.

Global energy consumption is predicted to improve by more than 50% through 2050, driven by developed and developing nations (EIA, 2021). Energy utilization is expected to be led by the building and construction sector, residential electricity use, and income rise in developing nations (EIA, 2021). However, even though renewable energy resources are considered the future energy source, fossil energy resources will be expected to maintain a significant share of the energy demand. With the structural changes of the world's developing economies are going through rapid economic development, trade openness, urbanization, and consumption of fossil fuel-based energy, continuous increase in carbon emission contribute to global warming as well as climate change (Ahmed et al., 2022; Pachiyappan et al., 2021; Prince Nathaniel et al., 2021). While carbon dioxide emissions in emerging nations continue to increase, emerging economies will be expected to experience even 127% greater emissions than those found in developed countries through 2040 (EIA, 2013). Whereas average global urbanization has exceeded 50% during the year in 2010, developing countries are expected to achieve the level of 50% in 2020, and they will increase further to 67% by 2050 (UNPD 2007). In contrast, the values of global trade openness have been found to rise by 9.5% percent between 2015 and 2021, according to reports from the World Development Indicator (WDI, 2021). During the period (2018–2023), renewable energy sources such hydropower, solar PV, wind, and bioenergy are predicted to provide around 70% of the global increase in electricity generation. The worldwide electricity demand (3%), by 2023, will be met by hydropower (16%), wind (6%), solar PV (4%), and bioenergy (IEA, 2018).

Among the different variables is also a major determinant that impacts the country's energy consumption. In this connection, the empirical literature focused on the impact of trade openness (TO), technological innovations, urbanization, financial growth, economic growth, carbon emissions and REU and N-REU. The impact of open trade on total energy use is disproportionately favorable to renewable energy. Likewise, Khan et al. (2020) and Nathaniel et al. (2021) suggest that trade internationally has a positive link to renewable energy in the country. The research proposes international trade with a particular emphasis on renewable energies. Increasing renewables use can also be vitally important to maintain and improve the sustainable environment (Ponce et al., 2021) during the discussion on the existing link of trade-liberalization with and consumption of energy. Thus, the improvement in renewable energy use caused by technological innovations contributes to the quality of the environment, as REU is eco-friendly (Khan et al., 2021; Suki et al., 2022). In addition, earlier research (Alam and Murad, 2020; Zhou et al., 2010) has shown that technological advancements are also necessary to increase energy efficiency, which encourages manufacturers to move from the conventional to the renewable energy sector. Similar to this, there are a number of obstacles in the way of the transition from the traditional energy industry to the renewable energy sector. Viardot (2013) has listed a few of these obstacles, including those related to financial restraints, additional societal and legal restrictions, and technological innovation limitations. Economic actors, who believe that energy use defers based on technological improvements, therefore face a hurdle in shifting to the utilization of renewable energy (Gezahegn et al., 2018).

Research has explored how urbanization affects the REU and N-REU (Hossain, 2011; Neill et al., 2012). Specifically, although some researchers enlisted financial development and open trade, others regarded only the use of energy, urbanization, and trade openness (Salari et al., 2021). Consumption of energy was also identified as a system whereby financial growth has an impact on the environmental degradation (Alam and Alam, 2021; Jahanger et al., 2022; Ozcan et al., 2020) as the financial growth promotes investing in ecologically sustainable technology that can help to cut CO_2 emissions. Similarly, the present literature about the link between financial-growth-energies-environmental highlights the direct effect of these variables on ecological damage (Usman et al., 2022). In this case, sound financial markets are necessary to increase capital mobility allocation, just as a stable financial system is needed to support, finance, and manage the risks involved in the shift from the non-renewable to the renewable energy sector. A strong financial system is required to increase investment in the industrial sector, and underdeveloped economies might not make such investments (Wurgler, 2000). Consequently, a significant financial role is needed in an atmosphere where the renewable energy sector is encouraged.

Between the key variables, energy use is conditional on attaining ecologically sustainable economic development (Zaman and Kalirajan, 2019). The demand for natural resources increases with gross domestic product, which lowers biocapacity and increases the ecological footprint (Lorente et al., 2023). The reason for this is that burning energy sources simultaneously drives the development of the economy (Majewski et al., 2022; Ozcan and Ozturk, 2019), and it affects the eco-friendly condition (Salahuddin et al., 2018). For example, the consumption of fossil fuels-led economic development is likely to cause high CO_2 emissions (Kanat et al., 2022), whereas achieving economic development using renewable sources may be determined to reduce those emissions (Mohammad and Alam, 2021; Saint Akadiri and Adebayo, 2022). Therefore, diversifying its energy mixers by decreasing and rising REU and N-REU shares can also be determined to make it easier for ecologically sustainable development (Shakib et al., 2022). Thus, for those specific countries, ecologically sustainable economic development could be either obtained using relatively fewer unclean fossil energies (Manigandan et al., 2021; Murshed et al., 2021; Rej et al., 2022; Wang et al., 2022) or by upgrading the effectiveness of energy usage (Hassan et al., 2022). The lack of funding, environmental externalities, the emphasis on importing filthy technologies, and social behaviour of the general public are examples of market failures that have prevented many countries from making the switch from non-renewable to renewable energy. In order to develop policy-oriented research at the macroeconomic level in the form of technological innovations, energy efficiency, and renewable energy use, it is implied that several empirical investigations are required. Due to this prevailing gap, the motivation of the paper has been raised purely by studying the relevant literature, as none of the studies exists that simultaneously focus on the relationship of trade openness, technological advancements, urbanization, financial growth, economic development, and carbon emissions on renewable, and non-renewable energy consumption.

The study contributes to the existing literature from the following aspects. Firstly, most of the previous studies discussed either renewable energy or non-renewable energy consumption with trade openness, technological advancements, urbanization, financial growth, economic development, and carbon emissions separately. Therefore, this study contributes to the literature by adding both types of energy consumption in a single study which may provide detailed insight into the degree of influence of all variables for both renewable energy and non-renewable energy consumption in India. Secondly, the results of this study provide information about the relative degree of renewable and nonrenewable energy consumption in response to trade openness, technological advancements, urbanization, financial growth, economic development, and carbon emissions in India. Thirdly, we conduct an empirical analysis using the quantile regression technique, which may yield more detailed data on trade, innovation, financial and economic growth, and urbanization policies for various quantiles of energy consumption-both renewable and non-renewable.

The claim of this research is novel, as the paragraph above makes clear, because no thorough study has been done in the past to examine how trade openness, technological advancements, urbanization, financial growth, economic development, and carbon emissions affect the consumption of renewable and non-renewable energy in the context of India. In the case of India, it's possible that the precise impact of trade liberalization, technical developments, urbanization, financial expansion, economic development, and carbon emissions on renewable and non-renewable energy is unknown. Thus, the purpose of this study is to examine how various factors affect India's consumption of both renewable and non-renewable energy sources.

The following section contains a brief review of relevant studies. Section 2 consists of a step-by-step earlier empirical literature; Section 3 illustrates the data and empirical methodology used for this analysis; The empirical outcome analysis is shown in Section 4; Finally, the conclusion of the research with the report's policy recommendations is presented.

2. Review of literature

2.1. The nexus between trade openness and REU and N-REU

Although studies on the consumption of energy and trade openness are generally found in the literature review, these analyses either assess energy use as a total or focus on traditional fossil fuel-based energy sources (Nasreen and Anwar, 2014; Sadorsky, 2012; Shahbaz et al., 2014). Although Mukhopadhyay (2009) assesses open trade as an important variable that contributes to CO_2 emissions and contributes to the consumption of energy. A relevant study by Esmaeili et al. (2023) examines the impacts on ecological footprint of trade openness, natural resource rents, social wellbeing, and economic policy uncertainty.

The dynamic connection of trade openness using both REU and N-REU has been investigated in the current works of literature. Related to this, Amri (2019) examines that trade positive and negative relationship impacts both REU and N-REU. Similarly, Parsa and Sajjadi (2017) and Tawfik et al. (2019) investigate the significant linkage between TO on the utilization of energy. Furthermore, Khoshnevis and Shakouri (2017) emphasize the importance of TO in increasing the volume of renewable and non-renewable energies usage in the South African environment. Similarly, Hdom and Fuinhas (2020) emphasizes a two-way nexus between the utilization of energy and trade in Brazil's environment and recommends the adoption of renewable energies as useful in decreasing CO_2 emissions. Likewise, various related studies have found a comparable positive nexus between trade openness through energy use (Farhani and Shahbaz, 2014; Jalil and Mahmud, 2009). Likewise, trade openness is also indicated in different earlier literature that contributes to the size of renewable energy use in numerous nations (Ullah et al., 2019). While in a likewise explore mixed findings have been informed, both REU and N-REU are found to have a relationship to economic development (Awodumi and Adewuyi, 2020). Akbar and colleagues (2021) contend that trade liberalization has a positive impact on energy consumption, encompassing both renewable and non-renewable sources.

2.2. The nexus between technological innovation and REU and N-REU

Several studies have been conducted about the effect of technology innovation on REU and N-REU for various examples of countries using different economic approaches and found different findings. Kula (2014) and Tugcu and Tiwari (2016) investigated how the use of renewable energy has aided in the reduction of CO_2 emissions as well as advancements in economic performance and technical innovation. Khan et al. (2020) discovered how technological advancements affect both renewable and non-renewable resources, strengthening the environmental Kuznets theory. Similarly, Alam and Murad (2020) look into how economic expansion and technology advancement affect the use of renewable energy in OECD countries in different ways.

Technological innovations are thought to be important for economic growth, although a rise in economic activity increases the emission of CO_2 through efficiency (Su et al., 2021). For instance, in Malaysia, an analysis carried out by Suki et al. (2022) researched the role of innovation in ecological conditions. By utilizing the B-ARDL model, the results indicated that REU and technology reduce ecological pollution and environmental footprint. Their investigation further proves the assumption of the EKC. According to research by Murshed and Alam (2021), technological innovation has a part in lowering per capita totals, N-REU primary sources, and electrical energy use levels while raising per capita levels of electrical energy use and renewable primary sources. Likewise, it has been suggested in the literature that technical innovation can aid in the development of systems that can control, monitor, and limit the use of environmental degradation resources (Murshed, Rahman, et al., 2021). Likewise, Demircan Çakar et al. (2021) reviewed the effect of technology innovations on emissions of CO_2 in Mediterranean nations for the running periods 1997 to 2017. Through the application of the panel-cointegration method, they have identified a positive relationship between technical advancements and CO_2 emissions. Additionally, a number of studies have found a comparable positive correlation between technological advancements and CO_2 emissions (Adebayo et al., 2021; Khan et al., 2020; Kirikkaleli and Adebayo, 2021; Li et al., 2021).

2.3. The nexus between urbanization and REU and N-REU

A summary review of the literature revealed that the impact of urbanization might be either positive or negative on the consumption of total energy (REU and N-REU). Three ways could influence energy usage because of urbanization. First, social concerns, including household utilization and economic growth such as industrial development and manufacturing, may lead to increased energy use in economics (Poumanyvong et al., 2012). Second, urbanization increases the amount of energy consumed as a unit of measurement due to the intricate relationships between social, technological, and economic activities (Sadorsky, 2014; Ye et al., 2013). Third, solid policies and involvements may alternate this course of energy utilization in urbanization growth (Bernardini and Galli, 1993). Likewise, Larivière and Lafrance (1999) found a positive connection between urbanization and energy utilization, whereas Hossain (2011) found a negative linkage between energy utilization and urbanization in nine developing countries. Numerous studies have explored urbanization interconnection with energy use (Zhang and Lin, 2012). Analysis by Han et al. (2022) revealed similar footprints in several other studies. However, Zhou et al. (2012) argue that there is a negative correlation between energy use and the process of urbanization. Research has examined the relationship between energy usage and urbanization (Shahbaz et al., 2015).

2.4. The nexus between financial development and REU and N-REU

Existing empirical studies provide sufficient evidence by identifying the positive connection between financial growth and REU and N-REU. The results suggest that the economy's energy consumption is being overstated due to financial growth (Alam et al., 2022; Ouyang and Li, 2018; Samour et al., 2022). It is reasonable to assume that a well-functioning financial system will spur economic expansion through enhancing investment diversification, which will ultimately boost the need for energy to explore investment opportunities.

Ali Raza et al. (2020) explored the connection between the financial growth in nations with highly renewable energy utilization using a P-STR approach running from 1997 to 2017. The findings revealed that the financial development indices improve renewable energy use. However, they have varying effects on renewable energy use. Likewise, Wang and Dong (2021) use a fixed effect and panel threshold model applying G20 countries' datasets from 2005 and 2018 to find the symmetric and asymmetric effects of financial growth on renewable energy utilization. Although, when urbanization and technologies exceed certain threshold values, financial growth has a significant and positive asymmetric influence on renewable energy utilization. Utilizing dynamic evaluators in 21 countries in the developing world running from 1970 to 2018. Khan et al. (2021) determined that resources of renewable energies improve environmental degradation compared with non-renewable sources, although financial development reduces the environmental degradation. Recent research on the relationship between REU and N-REU financial growth and the global setting used in the current econometric technique examines a positive relationship between financial growth and REU and N-REU consumption (Lu et al., 2021; Zhe et al., 2021).

2.5. The nexus between economic growth and REU and N-REU

A few recent research looked into the potential relationship between economic development and REU and N-REU utilization. For instance, Abbasi et al. (2020) used the NARDL approach to investigate the asymmetry relationship between the REU and N-REU influence on Pakistan's GDP. Their empirical results demonstrate that the negative and positive shocks to renewable energy were a robust long-term nonlinear nexus on economic growth. They also found that N-REU had a negative and substantial effect on economic development. Shastri et al. (2020) reviewed the nexus between the economic development, REU and N-REU in India running from 1971 to 2017, they employed the NARDL model and a nonlinear causality test. Long-term economic development in India has been found to be enhanced by positive shocks to REU and N-REU; however, negative turbulence in non-renewable consumption has a more detrimental influence on economic growth. Shahbaz et al. (2017) investigated India's uneven relationship between energy consumption and economic development using the NARDL model. They found that shocks to negative energy use had an adverse effect on economic growth. According to Balsalobre-Lorente et al. (2024), the growth of exports is linked to manufacturing and the use of resources like energy, oil, fossil fuels, and money.

The study (Rahman and Velayutham, 2020) evaluated the link between REU and N-REU on economic development in the South Asian nations from 1990 to 2014. This study reveals the positive effect of REU and N-REU and fixed capital development on economic development. Ivanovski et al. (2021 used the non-parametric approach to explore the link between the REU and N-REU and economic development in OECD and non-OECD panels from 1990 to 2015. The outcomes suggested that N-REU is making a positive and substantial effect on economic development all over OECD countries. Equally, REU and N-REU improve economic development in non-OECD nations. On the other hand, this economic expansion is also linked to environmental problems and raises greenhouse gas emissions (GHGs), which have an adverse effect on the environment (Balsalobre-Lorente et al., 2024).

2.6. The nexus between CO_2 emissions and REU and N-REU

The relationship between energy use and environmental degradation is based on empirical findings on the relationship between REU and N-REU and environmental degradation (CO_2 emissions). For example, Nathaniel and Iheonu (2019) studied the role of N-REU and REU on a decrease in emission of CO_2 in Africa running from 1990 to 2014. The outcomes suggest that renewable energy use reduces the emissions of CO_2 statistically insignificantly, whereas the N-REU is increasing the emissions of CO_2 substantially, and the effect of both energies varies between the regions. The usage of renewable energy lowers CO_2 emissions, but N-REU and economic growth worsen environmental degradation, according to research by Salahuddin et al. (2020) on the function of REU and N-REU and economic growth in Sub-Saharan Africa. Moreover, the transition from the traditionally N-REU fossil fuels to REU substitutes has been credited with lowering CO_2 emissions (Hamid et al., 2022; Murshed, 2020). In the last few years, a flurry of research has explored the useful role of REU in correcting environmental degradation (Murshed et al., 2022). Likewise, several previous research studies have found the CO_2 emissions effects of renewable and non-renewable energy utilization (Murshed, 2021; Murshed, Ahmed, et al., 2021). In contrast, Rafei et al. (2022) looked at how economic complexity, the use of renewable energy, natural resources, and foreign direct investment affected the ecological footprint in 1995–2017 in nations with poor, medium, and high institutional quality.

After examining a large body of empirical research, we discovered that there is a good exploration of the effects of trade openness, urbanization, financial and technological advancements on the environment. Still, their role in renewable, and non-renewable energy is under-researched, and obtained results are inconclusive. Therefore, additional research is needed to address the debate surrounding trade openness, inventions, urbanization, financial growth, economic development, and carbon emissions from both renewable and non-renewable energy sources. More significantly, there aren't any research that we are aware of that compare the outcomes by country for India. Consequently, our goal in this study was to offer important policy recommendations based on the aforementioned goals.

3. Data collection and methodology

3.1. Data collection

The current empirical investigation the impact of trade openness, technological innovations, urbanization, financial development, economic development, and emission of CO_2 on renewable and non-renewable energies used using an annual dataset of India country spanning from 1980 to 2020. Moreover, indicate the estimations of the parameters. All the variables are transformed into natural logarithmic and revealed to the per capita. The data were sourced from the World Development Indicators (WDI) online database (World Bank, 2022) and the British Petroleum (BP 2022) database for India country. All the variables utilized in this study are defined, and data sources are listed in **Table 1**.

Table 1. Variables used in this research, abbreviation, descriptions, and sources.

Variables	Abbreviation	Description	Sources
Renewable energy	REC	'Per capita (Kwh)'	BP
Non-renewable energy	NREC	'Per capita (Kwh)'	
Trade openness	TO	'Trade % of GDP'	WDI
Technological innovations	TI	No. of patent applications with residents	
urbanization	UR	Urban population (% of total populations)	
Financial development	FD	Domestic credit to the private sector (% of GDP)	
Economic growth	GDP	Real GDP based on 2010 US$	
CO_2 emissions	CO_2	Metric tons per capita	BP

3.2. Model specification

According to the EKC hypothesis (Alola et al., 2019; Hamid et al., 2021; Nathaniel et al., 2019; Pata and Caglar, 2021), the empirical pattern applied in this research is determined. This study uses two models to analyze the impact of trade openness, technology innovations, urbanization, financial growth, economic development, and CO_2 emission on REU and N-REU (dependent variable) in India was explored using a natural logarithm linear model and can be expressed as follows Equations (1) and (2):

$$\ln REU_{it} = \delta_0 + \delta_1 \ln TO_{it} + \delta_2 \ln TI_{it} + \delta_3 \ln UR_{it} + \delta_4 \ln FD_{it} + \delta_5 \ln GDP_{it} + \delta_6 \ln CO2_{it} + \varepsilon_{it} \quad (1)$$

$$\ln NREU_{it} = \delta_0 + \delta_1 \ln TO_{it} + \delta_2 \ln TI_{it} + \delta_3 \ln UR_{it} + \delta_4 \ln FD_{it} + \delta_5 \ln GDP_{it} + \delta_6 \ln CO2_{it} + \varepsilon_{it} \quad (2)$$

In the above equations, the REU, N-REU, TO, TI, UR, FD, GDP, CO_2, and shows the Renewable and Non-renewable energies, trade open, technological innovations, urbanization, financial growth, economic growth, CO_2 emission, and error term of models 1 and 2 respectively.

3.3. Methodology

Our analysis method of choice is quantile regression, which yields estimates of dependent variables in the response of explanatory factors at various places along the conditional distribution of the dependent variable (Eide and Showalter, 1998). The average influence of the independent factors on the dependent variable serves as the basis for the typical least squares regression estimate technique, which provides a summary of the averages of the distributions corresponding to the set of independent variables (Coad and Rao, 2008). Nevertheless, we can estimate many regressions corresponding to the different percentage points of the distributions, thereby obtaining a more comprehensive picture of the set. The traditional regression estimates show the model-based conditional mean of a dependent variable.

While the conditional median is the basis for the quantile regression approach, the simple regression is based on the Koenker and Bassett (1978). A number of reactions to the dependent variable are captured by the quantile regression analyses as a result of changes in the independent variables (Jareño et al. 2020; Jareño et al. 2016; Sevillano and Jareño, 2017). According to Anh et al. (2017), the quantile regression estimates provide a more thorough explanation of the estimations and enable us to calculate the heterogeneous influence of dependent variables resulting from differences in the explanatory factors across quantiles. For instance, we can evaluate how the explanatory variables affect the dependent variables in the quantiles of 10 and 95. Furthermore, quantile regression yields more robust estimations even in the presence of data outliers, as demonstrated by Jarreño et al. (2016) and does not adhere to the restrictive assumption of the identical distribution of error terms as stated by Ferrando et al. (2017). Following the methodology of Koenker and Bassett, (1978), we arrive at the quantile regression Equation (3) that follows:

$$z_q(y_j) = y_j'\delta_q + \varepsilon_j \tag{3}$$

where *z* and indicate the dependent variables. However, $z_q(y_j)$ refers to the usage of renewable and non-renewable energies at 0.10% to 0.90% quantiles in residence j y_j. y_j' indicates the vector of observable explanatory variables of each renewable and non-renewable energy use j that may impact trade openness, technology innovations, urbanization, financial growth, economic development, and CO_2 emission. ε_j indicates the error terms of the model assumed to be uncorrelated with y_j' (Jareño et al., 2020). $\delta_q$the different impact of the explanatory variables, while in the vector of the unknown coefficient associated were the q-th quantiles $(0 < q < 1)$. We can rewrite the conditional quantile of y_j given y_j' as Equation (4) follows:

$$Q_q\left(\frac{y_j}{y_j'}\right) = y_j'\delta_q \tag{4}$$

The following is how Koenker and Bassett (1978) intended quantile estimation via minimizing of Equation (5):

$$\underset{\delta_q}{Min} \sum_{j:z_j \geq y_j'\delta_q}^{n} q\left|z_j - y_j'\delta_q\right| + \sum_{j:y_j < y_j'\delta_q}^{n} (1-q)\left|z_j - y_j'\delta_q\right| \tag{5}$$

where z_j indicates the REU and N-REU in residence$j$. y_j' is explanatory variables, δ_q is the coefficient vector, and 1 denote the quantile to be estimated. The specific quantile being evaluated will determine how the coefficient vector δ_q is calculated. Sevillano and Jareño (2018) state that the quantile regression method employs linear programming with the simplex algorithm or the generalized method of moments for estimations. In accordance with the selected quantile, Equation (6) distributes the appropriate weight and minimizes the weighted error terms (Jareño et al., 2020b; Sevillano and Jareño, 2017). Equation (6) can be rewritten as follows using the quantile regression method:

$$NREU_t = \delta_0^q + \delta_1^q TO_t + \delta_2^q TI_t + \delta_3^q UR_t + \delta_4^q FD_t + \delta_5^q GDP_t + \delta_6^q CO2_t + \varepsilon_t \tag{6}$$

$$REU_t = \delta_0^q + \delta_7^q TO_t + \delta_8^q TI_t + \delta_9^q UR_t + \delta_{10}^q FD_t + \delta_{11}^q GDP_t + \delta_{12}^q CO2_t + \varepsilon_t \tag{7}$$

$\delta_i^q i = 0, 1, 2, \ldots, 12$ is the quantile regression coefficients for the model 1 and model 2 in which non-renewable energy and renewable energy is the dependent variable, q-th denote the number of quantile regressions that ranges from 0.10 to 0.90 quantiles. In the end, it deploys conventional techniques such as FE-OLS, D-OLS, and FM-OLS to compare the results with the advanced techniques.

4. Result and discussion

4.1. Descriptive statistics

This study explores the nexus between trade openness, technology innovations, urbanization, financial growth, economic development, and CO_2 emission on REU and N-REU for India through data running from 1980 to 2020. We examined the median, mean, minimum, maximum, kurtosis values, skewness, and standard deviation. **Table 1** indicated that summary statistics for the selected variables were used in this research. The skewness statistics of the normally distributed must be equivalent to one, and kurtosis statistics of the normally distributed should be equivalent to zero, according to the skewness and kurtosis statistics criteria. This except technological innovations and renewable energy variables is normally distributed for variables under study, according to data from Jarque-Bera test statistics shown in **Table 2**.

Table 2. Outcomes of descriptive statistics

Variable	*N*	Mean	Median	Max	Min.	Std. D	Skew.	Kurt.	JB-test	*p*-values
TO	27	29.93	25.40	55.79	12.22	14.65	0.35	−1.43	3.88	0.143
TI		4951.88	2226.50	19454.00	982.00	5058.58	1.21	0.33	10.906	0.004
UR		28.11	27.56	34.47	23.10	3.28	0.31	−1.13	2.4392	0.295
FD		34.28	27.46	52.39	20.54	12.08	0.44	−1.65	5.5393	0.062
GDP		894.10	750.16	1972.76	387.64	466.19	0.84	−0.51	5.3653	0.068
CO_2		1.01	0.92	1.92	0.42	0.46	0.60	−0.89	3.6357	0.162
REU		7.45	7.01	12.74	5.03	1.70	1.35	1.73	19.652	0.000
NREU		3464.20	3175.90	6303.31	1498.97	1449.50	0.49	−1.01	3.0751	0.214

Source: Author's computation.

Table 3. Outcomes of unit root tests.

Variable	ADF		PP		ZA			
	I (0)	I (1)	I (0)	I (1)	I (0)	Break year	I (1)	Break year
TO	−1.2502	−3.1807**	−5.3441	−33.745***	−3.045	2003	−7.3325***	2011
TI	−2.7201	−4.2889***	−5.3199	−37.926***	−4.0584*	2016	−6.9356***	2017
UR	−2.61597	−4.9851***	1.2961	−14.214**	−2.8747	1997	−5.262***	1989
FD	−2.8766	−5.4932***	−4.3181	−41.225***	−2.6503	2003	−7.0337***	1997
GDP	−1.2378	−4.3449***	−1.9464	−34.062***	−1.6591	1999	−5.1517***	2012
CO_2	−2.6439	−3.9112**	−7.2081	−47.9***	−4.6707*	2000	−8.3786***	2005
REU	−1.231	−4.1619***	−6.8169	−38.062***	−4.4145*	2003	−7.3896***	1982
NREU	−3.5573**	−3.0019***	−9.2758	−52.973***	−5.4415**	2000	−8.7024***	2003

Source: Author's computation. The signs ***, **, and * indicate the statistical significance levels at 1%, 5%, and 10%, respectively.

Moreover, before implementing the quantile regression and instrumental variables quantile regression approach, it is necessary to note that the variables have a unit root and are stationary at the first-order difference I (1) except N-REU and financial growth stationarity at the level I (0). The outcomes of the Phillips Perron, Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981; Phillips and Perron, 1988). and Zivot and Andrews (ZA) (Zivot and Andrews, 1992) tests for determining unit roots are shown in **Table 3**. All unit root test shows that all variables are nonstationary at the level and become stationary at first differences, such that the order of integration is I (0) or I (1). Further, based on their first-order difference, the null hypothesis of unit root tests can be firmly rejected for the significant variables at the 10%, 5%, and 1% statistical significance levels.

4.2. Outcomes of quantile regression

Before applying quantile regression, evaluate the impact of influencing variables on REU and N-REU and economic development. The use of Non-renewable and Renewable sources needs to be divided. The existing relevant research carefully selects nine representative quantiles points for analysis, namely 0.10, to 0.90% respectively. The QR analysis of REU and N-REU are represented in **Tables 4** and **5**. The impact of TO, technological innovations, urbanization, financial growth, economic development, and CO_2 emission as independent factors on REU (dependent variable) is represented in **Table 4**.

Table 4. Renewable energy model.

	Quantiles								
Variables	***q*-10th**	***q*-20th**	***q*-30th**	***q*-40th**	***q*-50th**	***q*-60th**	***q*-70th**	***q*-80th**	***q*-90th**
TO	−0.500*** (0.054)	−0.423** (0.146)	−0.340* (0.160)	−0.263 (0.176)	−0.343 (0.186)	−0.333* (0.133)	−0.360** (0.109)	−0.378*** (0.058)	−0.224 (1.931)
TI	0.434*** (0.070)	0.482** (0.157)	0.667* (0.253)	0.622* (0.232)	0.932** (0.281)	0.770** (0.240)	0.802*** (0.190)	0.593*** (0.121)	0.523** (1.427)
UR	−18.850*** (1.564)	−17.127** (5.197)	−3.691*** (6.757)	−5.165* (5.332)	5.008 (5.984)	3.689 (4.570)	3.179 (3.221)	−0.450* (2.270)	−0.925*** (13.010)
FD	0.270** (0.157)	0.229 (0.248)	0.033** (0.286)	−0.002*** (0.170)	−0.339*** (0.255)	−0.244*** (0.220)	−0.141** (0.177)	−0.044* (0.092)	−0.240*** (0.736)
GDP	2.098*** (0.476)	1.855* (0.908)	−0.649 (1.427)	0.062*** (1.286)	2.324** (1.420)	−1.705** (1.203)	−1.867 (0.966)	0.879*** (0.595)	0.289* (2.433)
CO_2	1.548** (0.453)	1.217 (0.766)	0.254 (0.868)	0.015 (0.889)	−0.448*** (0.936)	−0.533*** (0.589)	−0.323** (0.439)	−0.326* (0.250)	−0.491** (1.422)

Source: Authors computation *, **, and *** show the levels of demonstrated significance at 10%, 5%, and 1%, respectively. Parentheses represent standard errors. *q* = Quantiles.

According to the quantile regression analysis, the effect of TO on renewable energy is negative and statistically significant at the quantiles is 0.10% to 0.90% except for the 0.40% and 0.50% quantiles, and the effect of the development on REU is strong at the highest quantiles. This result aligns with the studies of Amri (2019); Zeren and Akkuş (2020). Again, the influence of technological innovations on renewable energy is positive and demonstrated significance at the quantiles is 0.10% to 0.90%. These findings indicate that the impact of the improvement on REU is strong at the greatest quantiles. Additionally, research has indicated that technology innovations positively influence REU (Rahman et al., 2022). Furthermore, green innovations play a crucial role in curbing greenhouse gas emissions (Balsalobre-Lorente et al., 2023).

The impact of urbanization is either negative or statistically significant for 0.10% to 0.90% quantiles except for the 0.50% to 0.70% quantiles. Renewable energy increases significantly with urbanization, and the effect is greater in more quantiles. In exploring the connection between urbanization and renewable energy utilization, some literature found that urbanization negatively influences REU (Islam et al., 2022). Economic development demonstrated a significant and positive impact on renewable energy at 0.10% to 0.90%, except for the 0.30% and 0.70% quantiles that showed a statistically significant nexus with renewable energy. The findings indicate that the positive effect of economic development on renewable energy is also the same as previous literature (Anwar et al., 2021; Bogusław et al., 2022; Ohlan, 2016). Furthermore, the outcomes show that financial development is positively, negatively, and statistically insignificant with renewable energy in the quantiles 0.10% to 0.90% except for the 0.20% quantile. At the same time, some studies found a significant and positive nexus between financial development and REU. For instance, Khan et al. (2021); Khan et al. (2020); Mukhtarov et al. (2022) results in the financial development and renewable energy connection.

This effect of carbon emissions on renewable energies is positive and demonstrated significance only in the quantiles 0.10%, negative quantiles from 0.50% to 0.90%, the remaining quantiles from 0.20% to 0.40% statistically insignificant with renewable energy. The current literature also suggests the positive effect of carbon emission on renewable energy utilization (Khan et al., 2020; Vural, 2020). The previous researchers also support the reverse impact of renewable energy use on the emission of CO_2 (Anwar et al., 2021). In addition, **Figure 1** shows graphical representations of empirical results on renewable energy consumption.

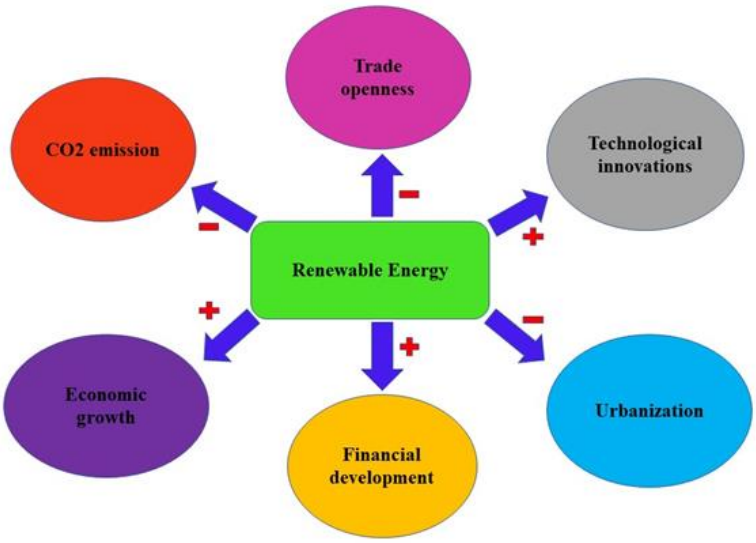

Figure 1. Graphical reports of the empirical results on renewable energy.

Likewise, the previous results, the impact of trade openness, technology innovations, urbanization, financial growth, economic development, and CO_2 emission are taken as independent factors on N-REU is represented in **Table 5**. The effects of TO and urbanization on N-REU are positive and demonstrated the significance at the quantiles is 0.10% to 0.90%. These findings indicate that the effect of the improvement on N-REU is strong at the greatest quantiles. This result supported the researchers of Zeren and Akkuş (2020) and indicates that trade openness, urbanization, and non-renewable energies are positively and negatively related (Han et al., 2022; Islam et al., 2022).

Table 5. Non-renewable energy model.

	Quantiles								
Variables	***q*-10th**	***q*-20th**	***q*-30th**	***q*-40th**	***q*-50th**	***q*-60th**	***q*-70th**	***q*-80th**	***q*-90th**
TO	0.086*** (0.016)	0.065*** (0.014)	0.067** (0.021)	0.072*** (0.017)	0.075*** (0.019)	0.076*** (0.019)	0.072*** (0.018)	0.076** (0.025)	0.095 (0.073)
TI	−0.068*** (0.016)	−0.056* (0.021)	−0.058 (0.034)	−0.053*** (0.032)	−0.062*** (0.035)	−0.085* (0.036)	−0.048** (0.038)	−0.041*** (0.051)	−0.056* (0.072)
UR	1.614*** (0.363)	1.632*** (0.229)	1.694* (0.622)	1.880** (0.636)	2.44* (0.720)	3.551* (0.716)	1.071 (0.776)	5.100** (0.787)	6.235 (1.634)
FD	−0.055** (0.040)	−0.012 (0.022)	−0.007 (0.031)	−0.006* (0.026)	−0.015*** (0.031)	0.007*** (0.031)	0.540** (0.032)	0.981* (0.037)	1.657*** (0.093)
GDP	0.101** (0.077)	0.509** (0.093)	0.917* (0.177)	1.091*** (0.179)	1.067* (0.169)	2.051** (0.172)	1.018*** (0.182)	1.028*** (0.177)	2.088* (0.374)
CO_2	0.513*** (0.055)	0.593*** (0.052)	0.585*** (0.078)	0.602*** (0.065)	0.605*** (0.088)	0.892*** (0.086)	1.665*** (0.081)	1.683*** (0.071)	2.821*** (0.145)

Source: Authors computation *, **, and *** show the levels of demonstrated significance at 10%, 5%, and 1%, respectively. Parentheses represent standard errors. *q* = Quantiles.

The effect of technological innovations on N-REU is negative and demonstrated significant at the quantiles is 0.10% to 0.90% except for the 0.30% quantiles, and the impact of the improvement on N-REU is strong at the highest quantiles. Similar outcomes are also found in some literature (Murshed and Alam, 2021). Furthermore, the outcomes show that the development of financial is positively, negatively, and statistically insignificant with non-renewable energy in the quantiles 0.10% to 0.90% except for the 0.20% and 0.30% quantiles.

Next, the impact of economic growth on N-REU is positively and statistically significant at the 0.10% to 0.90% quantiles implying that economic development increases the non-renewable sources is stronger at the quantiles. Furthermore, these findings complied with the Ohlan (2016) research for India, Zhang and Zhang (2021) for China. Lastly, CO_2 emissions positively affect the N-REU for the quantiles of 0.10% to 0.90%. These outcomes are inconsistent with previous literature results (Djellouli et al., 2022; de Oliveira and Moutinho, 2022; Mujtaba et al., 2022). In addition, **Figure 2** shows graphical representations of empirical outcomes on non-renewable energy use.

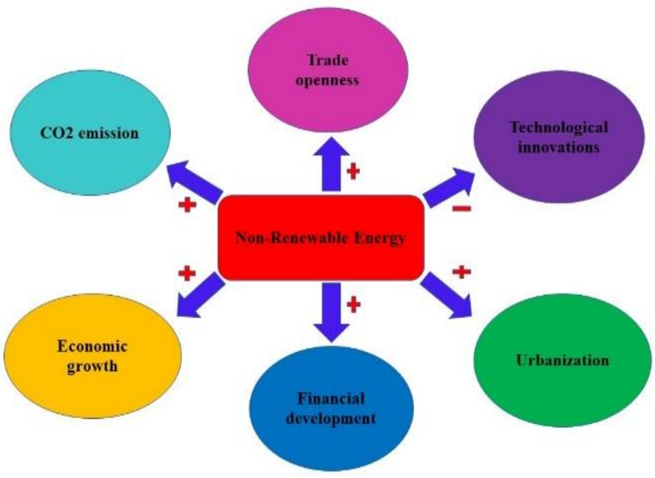

Figure 2. Graphical reports of the empirical outcomes on non-renewable energies.

4.3. Comparison with the outcomes of conventional methods

We used to estimate the impact of trade openness, technological innovations, urbanization, financial growth, economic development, and CO_2 emission on REU and N-REU using FE-OLS, D-OLS, and FM-OLS, the findings of which are shown in **Table 6**. We found that the effect of trade openness, urbanization, and carbon emission on REU is statistically significant and negative. This proves that while other variables are held constant, a 1% improvement in trade openness, urbanization, and carbon emissions in leads to a decrease of (−1.73%, −10.33%, −0.466%) FM-OLS, (−0.34%, −13.92%, 2.028%) D-OLS, (−0.40%, −4.15%, 0.351%) FE-OLS in renewable energy, respectively. Lastly, technological innovations, financial growth, and economic development in renewable energy are statistically significant and positive. This observation shows that while other variables are held constant, a 1% growth in technological innovations, financial growth, and economic development leads to a growth in renewable energy with (0.19%, 0.49%, 4.24%) FM-OLS, (2.24%, 0.97%, 3.67%) D-OLS, and (0.71%, 0.004%, −0.65%) FE-OLS, respectively, while other variables are held constant.

Table 6. The outcomes based on conventional methods FE-OLS, FM-OLS, and D-OLS.

Variables	FM-OLS		D-OLS		FE-OLS	
	Coefficient	**Statistic**	**Coefficient**	**Statistic**	**Coefficient**	**Statistic**
Renewable energy use						
TO	−1.732700***	0.075714	−0.341338*	0.142448	−0.40006***	0.116010
TI	0.190065*	0.073334	2.245459***	0.138676	0.713020***	0.196755
UR	−10.33534***	2.248438	−13.92846***	4.169095	−4.158206	3.775313
FD	0.493949***	0.074815	0.979139***	0.124043	0.004406	0.182836
GDP	4.245943***	0.299617	−3.674887***	0.553099	−0.657777	0.976266
CO_2	−0.466176*	0.170884	2.028376 ***	0.275364	0.351492	0.536831
Non-Renewable energy use						
TO	1.582924 ***	0.066958	0.059690***	0.109903	0.07363***	0.01497
TI	0.580458***	0.072593	−0.422992**	0.128070	−0.05885*	0.02539
UR	3.172160	1.758930	11.423572***	2.865634	1.52038**	0.48728
FD	0.655988***	0.062105	0.415694***	0.090483	−0.01527	0.02360
GDP	1.914689***	0.288354	5.082772***	0.496868	−0.02114	0.12601
CO_2	3.919737***	0.303998	4.015890***	0.641161	0.62955***	0.06929

Source: Author's computation, the signs ***, **, and * indicate the demonstrated significance level of the 1%, 5%, and 10%, respectively.

Similarly, the results present that trade openness, urbanization, financial growth, economic development, and carbon emissions have a positive and statistically substantial effect on N-REU use. 1% improvements in trade openness, urbanization, financial growth, economic development, and carbon emissions leads to rise in non-renewable energy with (1.58%, 3.17%, 0.65%, 1.91%, 3.91%) FM-OLS, (2.08%, 11.42%, 0.41%, 5.08%, 4.01%) D-OLS, and (0.07%, 1.52%, −0.01%, −0.02%, 0.62%) FE-OLS, respectively. In addition, the impact of technological innovations on non-renewable sources is statistically significant and negative. This outcome shows that while other variables are held constant, a 1% growth in technological innovations mitigates non-renewable energy with 0.58%~FM-OLS, −0.42%~D-OLS, and −0.05%~FE-OLS, respectively. In contrast, other variables are held constant.

5. Conclusion and policy recommendations

India has contributed significantly to the world and has made great strides in trade and innovation. Since India obtained the status of WTO member, it has achieved high GDP growth rates achieved, the resilience of the Indian economy to the global financial crisis, and the expansion of both. Over time, India shown remarkable growth in trade, and innovation activities, all of which strongly supported the use of both non-renewable and renewable energy sources. In addition, increased urbanization and economic expansion strain the energy supplies that are accessible. The major purpose of the studies is to explore the impact of TO, technological innovations, urbanization, financial growth, economic development, and carbon emission on the REU and N-REU in Indian countries running from 1980 to 2020. The study applied to the second-generation novel techniques such as FE-OLS, D-OLS, FM-OLS, and Quantile Regression (QR) models. We applied the quantile regression method for the empirical analysis, the quantile regression findings show that trade openness, urbanization, and CO_2 emissions negatively and significantly impact REU, whereas technological innovations, financial growth, and economic progress positively affect the REU. Similarly, technological innovations were negatively and statistically significant in connection with N-REU, whereas TO, urbanization, financial growth, GDP, and CO_2 emissions have been established that positively and statistically significant influence non-renewable energy utilization.

Furthermore, the outcomes of FE-OLS, D-OLS, and FM-OLS report that growth in REU will decrease TO, urbanization, and CO_2 emissions, whereas technological innovations, financial development, and economic development have an increased impact on the REU. Likewise, the FE-OLS, D-OLS, and FM-OLS report that growth in non-renewable energy utilization will decrease technological innovations, whereas trade openness, urbanization, financial growth, economic development, and emission of CO_2 have a positive effect on the N-REU.

Based on the empirical findings, some policy implications can be considered. To begin with, trade activities raise industrial production, and exports in turn increase the amount of energy consumed-both renewable and non-renewable that is used. Special laws should be implemented in this area to promote urbanisation and trade while maintaining environmental sustainability. Second, the environmental health of India will typically improve with the investment in technologies and the promotion of renewable energy consumption. However, regulations pertaining to money flow, technological advancement, and long-term economic policies in India are necessary for sustainable economic growth and the usage of renewable energy throughout the nation. Technological advancements would aid in the production of renewable energy as, in a similar vein, the rules for locating new and updated renewable resources would significantly expand the economies. Carbon emission plans are also required to encourage the purchase of renewable energy sources.

Corresponding to this, an additional important strategy in these nations might be increasing the price of conventional energy, which would deter manufacturers from focusing only on fossil fuels and instead encourage energy efficiency in this nation. Third, the results further propose that financial growth is essential for renewable energy usage. Countries should concentrate on improving their financial systems to provide the highest incentives for clean energy generation projects and research & development activities to encourage the REU, which is beneficial to the construction of a clean environment. Finally, the recommendations for high-emissions countries could improve the size of the population and economic development, which can help to reduce the emission of CO_2.

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References

Abbasi, K., Jiao, Z., Shahbaz, M., et al. (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

Adebayo, T. S., & Kirikkaleli, D. (2021). Impact of renewable energy consumption, globalization, and technological innovation on environmental degradation in Japan: application of wavelet tools. Environment, Development and Sustainability, 23(11), 16057–16082. https://doi.org/10.1007/s10668-021-01322-2

Ahmed, Z., Ahmad, M., Murshed, M., et al. (2021). The trade-off between energy consumption, economic growth, militarization, and CO_2 emissions: does the treadmill of destruction exist in the modern world? Environmental Science and Pollution Research, 29(12), 18063–18076. https://doi.org/10.1007/s11356-021-17068-3

Akadiri, S. S., & Adebayo, T. S. (2021). Asymmetric nexus among financial globalization, non-renewable energy, renewable energy use, economic growth, and carbon emissions: impact on environmental sustainability targets in India. Environmental Science and Pollution Research, 29(11), 16311–16323. https://doi.org/10.1007/s11356-021-16849-0

Akbar, M. W., Yuelan, P., Maqbool, A., et al. (2021). The nexus of sectoral-based CO_2 emissions and fiscal policy instruments in the light of Belt and Road Initiative. Environmental Science and Pollution Research, 28(25), 32493–32507. https://doi.org/10.1007/s11356-021-13040-3

Alam, M. S., Alam, M. N., Murshed, M., et al. (2022). Pathways to securing environmentally sustainable economic growth through efficient use of energy: a bootstrapped ARDL analysis. Environmental Science and Pollution Research, 29(33), 50025–50039. https://doi.org/10.1007/s11356-022-19410-9

Alam, Md. M., & Murad, Md. W. (2020). The impacts of economic growth, trade openness and technological progress on renewable energy use in organization for economic co-operation and development countries. Renewable Energy, 145, 382–390. https://doi.org/10.1016/j.renene.2019.06.054

Alam, Md. Q., & Alam, Md. S. (2021). Financial Development, Economic Growth and Poverty Reduction in India: An Empirical Evidence. ETIKONOMI, 20(1), 13–22. https://doi.org/10.15408/etk.v20i1.18417

Ali Raza, S., Shah, N., Asif Qureshi, M., et al. (2020). Nonlinear threshold effect of financial development on renewable energy consumption: evidence from panel smooth transition regression approach. Environmental Science and Pollution Research, 27, 32034–32047. https://doi.org/10.1007/s11356-020-09520-7

Alkhateeb, T. T. Y., & Mahmood, H. (2019). Energy Consumption and Trade Openness Nexus in Egypt: Asymmetry Analysis. Energies, 12(10), 2018. https://doi.org/10.3390/en12102018

Alola, A. A., Bekun, F. V., & Sarkodie, S. A. (2019). Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. Science of The Total Environment, 685, 702–709. https://doi.org/10.1016/j.scitotenv.2019.05.139

Amri, F. (2019). Renewable and non-renewable categories of energy consumption and trade: Do the development degree and the industrialization degree matter? Energy, 173, 374–383. https://doi.org/10.1016/j.energy.2019.02.114

Anh, L. H., Dong, L. S., Kreinovich, V., et al. (2018). Studies in Computational Intelligence. Springer International Publishing. https://doi.org/10.1007/978-3-319-73150-6

Anwar, A., Siddique, M., Eyup Dogan, & Sharif, A. (2021). The moderating role of renewable and non-renewable energy in environment-income nexus for ASEAN countries: Evidence from Method of Moments Quantile Regression. Renewable Energy, 164, 956–967. https://doi.org/10.1016/j.renene.2020.09.128

Awodumi, O. B., & Adewuyi, A. O. (2020). The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil producing economies in Africa. Energy Strategy Reviews, 27, 100434. https://doi.org/10.1016/j.esr.2019.100434

Balsalobre-Lorente, D., Contente dos Santos Parente, C., Leitão, N. C., et al. (2023). The influence of economic complexity processes and renewable energy on CO_2 emissions of BRICS. What about industry 4.0? Resources Policy, 82, 103547. https://doi.org/10.1016/j.resourpol.2023.103547

Balsalobre-Lorente, D., Nur, T., Topaloglu, E. E., et al. (2024). Assessing the impact of the economic complexity on the ecological footprint in G7 countries: Fresh evidence under human development and energy innovation processes. Gondwana Research, 127, 226–245. https://doi.org/10.1016/j.gr.2023.03.017

Balsalobre-Lorente, D., Nur, T., Topaloglu, E. E., et al. (2024). The dampening effect of geopolitical risk and economic policy uncertainty in the linkage between economic complexity and environmental degradation in the G-20. Journal of Environmental Management, 351, 119679. https://doi.org/10.1016/j.jenvman.2023.119679

Bernardini, O., & Galli, R. (1993). Dematerialization: Long-term trends in the intensity of use of materials and energy. Futures, 25(4), 431–448. https://doi.org/10.1016/0016-3287(93)90005-E

Coad, A., & Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. Research Policy, 37(4), 633–648. https://doi.org/10.1016/j.respol.2008.01.003

de Oliveira, H. V. E., Moutinho, V. (2022). Do renewable, non-renewable energy, carbon emission and KOF globalization influencing economic growth? Evidence from BRICS' countries. Energy Reports, 8, 48–53. https://doi.org/10.1016/j.egyr.2022.01.031

Demircan Çakar, N., Gedikli, A., Erdoğan, S., et al. (2021). A comparative analysis of the relationship between innovation and transport sector carbon emissions in developed and developing Mediterranean countries. Environmental Science and Pollution Research, 28, 45693–45713. https://doi.org/10.1007/s11356-021-13390-y

Dickey, D. A., & Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49(4), 1057. https://doi.org/10.2307/1912517

Djellouli, N., Abdelli, L., Elheddad, M., et al. (2022). The effects of non-renewable energy, renewable energy, economic growth, and foreign direct investment on the sustainability of African countries. Renewable Energy, 183, 676–686. https://doi.org/10.1016/j.renene.2021.10.066

EIA. (2013). International energy outlook with projections to 2040. Available online: https://www.eia.gov/outlooks/ieo/pdf/0484(2013).pdf (accessed on 1 July 2013).

EIA. (2021). International energy outlook with projections to 2050. Available online: https://www.eia.gov/outlooks/ieo/pdf/IEO2021_Narrative.pdf (accessed on 6 October 2021).

Eide, E., & Showalter, M. H. (1998). The effect of school quality on student performance: A quantile regression approach. Economics letters, 58(3), 345–350. https://doi.org/10.1016/S0165-1765(97)00286-3

Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. Science of The Total Environment, 663, 189–197. https://doi.org/10.1016/j.scitotenv.2019.01.323

Esmaeili, P., Rafei, M., Balsalobre-Lorente, D., et al. (2022). The role of economic policy uncertainty and social welfare in the view of ecological footprint: evidence from the traditional and novel platform in panel ARDL approaches. Environmental

Science and Pollution Research, 30(5), 13048–13066. https://doi.org/10.1007/s11356-022-23044-2

Farhani, S., & Shahbaz, M. (2014). What role of renewable and non-renewable electricity consumption and output is needed to initially mitigate CO_2 emissions in MENA region? Renewable and Sustainable Energy Reviews, 40, 80–90. https://doi.org/10.1016/j.rser.2014.07.170

Ferrando, L., Ferrer, R., & Jareño, F. (2015). Interest Rate Sensitivity of Spanish Industries: A Quantile Regression Approach. The Manchester School, 85(2), 212–242. https://doi.org/10.1111/manc.12143

Gezahegn, T. W., Gebregiorgis, G., Gebrehiwet, T., et al. (2018). Adoption of renewable energy technologies in rural Tigray, Ethiopia: An analysis of the impact of cooperatives. Energy Policy, 114, 108–113. https://doi.org/10.1016/j.enpol.2017.11.056

Hamid, I., Alam, M. S., Kanwal, A., et al. (2022). Decarbonization pathways: the roles of foreign direct investments, governance, democracy, economic growth, and renewable energy transition. Environmental Science and Pollution Research, 29(33), 49816–49831. https://doi.org/10.1007/s11356-022-18935-3

Hamid, I., Alam, M. S., Murshed, M., et al. (2021). The roles of foreign direct investments, economic growth, and capital investments in decarbonizing the economy of Oman. Environmental Science and Pollution Research, 29(15), 22122–22138. https://doi.org/10.1007/s11356-021-17246-3

han, J., Zeeshan, M., Ullah, I., et al. (2022). Trade openness and urbanization impact on renewable and non-renewable energy consumption in China. Environmental Science and Pollution Research, 29(27), 41653–41668. https://doi.org/10.1007/s11356-021-18353-x

Hassan, T., Song, H., Khan, Y., et al. (2022). Energy efficiency a source of low carbon energy sources? Evidence from 16 high-income OECD economies. Energy, 243, 123063. https://doi.org/10.1016/j.energy.2021.123063

Hdom, H. A. D., & Fuinhas, J. A. (2020). Energy production and trade openness: Assessing economic growth, CO_2 emissions and the applicability of the cointegration analysis. Energy Strategy Reviews, 30, 100488. https://doi.org/10.1016/j.esr.2020.100488

Hossain, S. M. (2011). Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy, 39(11), 6991–6999. https://doi.org/10.1016/j.enpol.2011.07.042

IEA. (2018). Renewables, Analysis and Forecasts to 2023 Executive Summary. IEA.

Islam, Md. M., Irfan, M., Shahbaz, M., et al. (2022). Renewable and non-renewable energy consumption in Bangladesh: The relative influencing profiles of economic factors, urbanization, physical infrastructure and institutional quality. Renewable Energy, 184, 1130–1149. https://doi.org/10.1016/j.renene.2021.12.020

Ivanovski, K., Hailemariam, A., & Smyth, R. (2021). The effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence. Journal of Cleaner Production, 286, 124956. https://doi.org/10.1016/j.jclepro.2020.124956

Jahanger, A., Usman, M., Murshed, M., et al. (2022). The linkages between natural resources, human capital, globalization, economic growth, financial development, and ecological footprint: The moderating role of technological innovations. Resources Policy, 76, 102569. https://doi.org/10.1016/j.resourpol.2022.102569

Jahanger, A., Yu, Y., Hossain, M. R., et al. (2022). Going away or going green in NAFTA nations? Linking natural resources, energy utilization, and environmental sustainability through the lens of the EKC hypothesis. Resources Policy, 79, 103091. https://doi.org/10.1016/j.resourpol.2022.103091

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. Energy Policy, 37(12), 5167–5172. https://doi.org/10.1016/j.enpol.2009.07.044

Jareño, F., Ferrer, R., & Miroslavova, S. (2016). US stock market sensitivity to interest and inflation rates: a quantile regression approach. Applied Economics, 48(26), 2469–2481. https://doi.org/10.1080/00036846.2015.1122735

Jareño, F., González, M. de la O., Tolentino, M., et al. (2020). Bitcoin and gold price returns: A quantile regression and NARDL analysis. Resources Policy, 67, 101666. https://doi.org/10.1016/j.resourpol.2020.101666

Kanat, O., Yan, Z., Asghar, M. M., et al. (2022). Do natural gas, oil, and coal consumption ameliorate environmental quality? Empirical evidence from Russia. Environmental Science and Pollution Research, 29, 4540–4556. https://doi.org/10.1007/s11356-021-15989-7

Khan, A., Chenggang, Y., Hussain, J., et al. (2021). Impact of technological innovation, financial development and foreign direct investment on renewable energy, non-renewable energy and the environment in belt & Road Initiative countries. Renewable

Energy, 171, 479–491. https://doi.org/10.1016/j.renene.2021.02.075

Khan, A., Hussain, J., Bano, S., et al. (2019). The repercussions of foreign direct investment, renewable energy and health expenditure on environmental decay? An econometric analysis of B&RI countries. Journal of Environmental Planning and Management, 63(11), 1965–1986. https://doi.org/10.1080/09640568.2019.1692796

Khan, H., Khan, I., & Binh, T. T. (2020). The heterogeneity of renewable energy consumption, carbon emission and financial development in the globe: A panel quantile regression approach. Energy Reports, 6, 859–867. https://doi.org/10.1016/j.egyr.2020.04.002

Khan, H., Weili, L., Khan, I., et al. (2021). Recent advances in energy usage and environmental degradation: Does quality institutions matter? A worldwide evidence. Energy Reports, 7, 1091–1103. https://doi.org/10.1016/j.egyr.2021.01.085

Khan, I., Han, L., Khan, H., et al. (2021). Analyzing Renewable and Nonrenewable Energy Sources for Environmental Quality: Dynamic Investigation in Developing Countries. Mathematical Problems in Engineering, 2021, 1–12. https://doi.org/10.1155/2021/3399049

Khan, S. A. R., Yu, Z., Belhadi, A., et al. (2020). Investigating the effects of renewable energy on international trade and environmental quality. Journal of Environmental Management, 272, 111089. https://doi.org/10.1016/j.jenvman.2020.111089

Khan, Z., Ali, M., Kirikkaleli, D., et al. (2020). The impact of technological innovation and public-private partnership investment on sustainable environment in China: Consumption-based carbon emissions analysis. Sustainable Development, 28(5), 1317–1330. https://doi.org/10.1002/sd.2086

Khoshnevis Yazdi, S., & Shakouri, B. (2017). Renewable energy, nonrenewable energy consumption, and economic growth. Energy Sources, Part B: Economics, Planning, and Policy, 12(12), 1038–1045. https://doi.org/10.1080/15567249.2017.1316795

Kirikkaleli, D., & Adebayo, T. S. (2020). Do renewable energy consumption and financial development matter for environmental sustainability? New global evidence. Sustainable Development, 29(4), 583–594. https://doi.org/10.1002/sd.2159

Koenker, R. (2005). Quantile Regression. https://doi.org/10.1017/cbo9780511754098

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

Kula, F. (2013). The Long-run Relationship Between Renewable Electricity Consumption and GDP: Evidence from Panel Data. Energy Sources, Part B: Economics, Planning, and Policy, 9(2), 156–160. https://doi.org/10.1080/15567249.2010.481655

Larivière, I., & Lafrance, G. (1999). Modelling the electricity consumption of cities: effect of urban density. Energy Economics, 21(1), 53–66. https://doi.org/10.1016/S0140-9883(98)00007-3

Li, Z. Z., Li, R. Y. M., Malik, M. Y., et al. (2021). Determinants of Carbon Emission in China: How Good is Green Investment? Sustainable Production and Consumption, 27, 392–401. https://doi.org/10.1016/j.spc.2020.11.008

Lorente, D. B., Mohammed, K. S., Cifuentes-Faura, J., et al. (2023). Dynamic connectedness among climate change index, green financial assets and renewable energy markets: Novel evidence from sustainable development perspective. Renewable Energy, 204, 94–105. https://doi.org/10.1016/j.renene.2022.12.085

Lu, J., Imran, M., Haseeb, A., et al. (2021). Nexus Between Financial Development, FDI, Globalization, Energy Consumption and Environment: Evidence from BRI Countries. Frontiers in Energy Research, 9. https://doi.org/10.3389/fenrg.2021.707590

Majewski, S., Mentel, U., Salahodjaev, R., et al. (2022). Electricity Consumption and Economic Growth: Evidence from South Asian Countries. Energies, 15(4), 1327. https://doi.org/10.3390/en15041327

Manigandan, P., Alam, M. S., Alharthi, M., et al. (2021). Forecasting Natural Gas Production and Consumption in United States-Evidence from SARIMA and SARIMAX Models. Energies, 14(19), 6021. https://doi.org/10.3390/en14196021

Mujtaba, A., Jena, P. K., Bekun, F. V., et al. (2022). Symmetric and asymmetric impact of economic growth, capital formation, renewable and non-renewable energy consumption on environment in OECD countries. Renewable and Sustainable Energy Reviews, 160, 112300. https://doi.org/10.1016/j.rser.2022.112300

Mukhtarov, S., Yüksel, S., & Dinçer, H. (2022). The impact of financial development on renewable energy consumption: Evidence from Turkey. Renewable Energy, 187, 169–176. https://doi.org/10.1016/j.renene.2022.01.061

Murshed, M. (2020). Are Trade Liberalization policies aligned with Renewable Energy Transition in low and middle income countries? An Instrumental Variable approach. Renewable Energy, 151, 1110–1123. https://doi.org/10.1016/j.renene.2019.11.106

Murshed, M. (2021). Modeling primary energy and electricity demands in Bangladesh: An Autoregressive distributed lag approach. Sustainable Production and Consumption, 27, 698–712. https://doi.org/10.1016/j.spc.2021.01.035

Murshed, M., & Alam, M. S. (2021). Estimating the macroeconomic determinants of total, renewable, and non-renewable energy demands in Bangladesh: the role of technological innovations. Environmental Science and Pollution Research, 28, 30176–30196. https://doi.org/10.1007/s11356-021-12516-6

Murshed, M., Ahmed, Z., Alam, S., et al. (2021). Reinvigorating the role of clean energy transition for achieving a low-carbon economy: evidence from Bangladesh. Environmental Science and Pollution Research, 28, 67689–67710. https://doi.org/10.1007/s11356-021-15352-w

Murshed, M., Alam, R., & Ansarin, A. (2021). The environmental Kuznets curve hypothesis for Bangladesh: the importance of natural gas, liquefied petroleum gas, and hydropower consumption. Environmental Science and Pollution Research, 28(14), 17208–17227. https://doi.org/10.1007/s11356-020-11976-6

Murshed, M., Haseeb, M., & Alam, Md. S. (2021). The Environmental Kuznets Curve hypothesis for carbon and ecological footprints in South Asia: the role of renewable energy. GeoJournal, 87(3), 2345–2372. https://doi.org/10.1007/s10708-020-10370-6

Murshed, M., Mahmood, H., Ahmad, P., et al. (2022). Pathways to Argentina’s 2050 carbon-neutrality agenda: the roles of renewable energy transition and trade globalization. Environmental Science and Pollution Research, 29(20), 29949–29966. https://doi.org/10.1007/s11356-021-17903-7

Murshed, M., Rahman, M. A., Alam, M.S., et al. (2021). The nexus between environmental regulations, economic growth, and environmental sustainability: linking environmental patents to ecological footprint reduction in South Asia. Environmental Science and Pollution Research, 28, 49967–49988. https://doi.org/10.1007/s11356-021-13381-z

Nasreen, S., & Anwar, S. (2014). Causal relationship between trade openness, economic growth and energy consumption: A panel data analysis of Asian countries. Energy Policy, 69, 82–91. https://doi.org/10.1016/j.enpol.2014.02.009

Nathaniel, S. P., & Iheonu, C. O. (2019). Carbon dioxide abatement in Africa: The role of renewable and non-renewable energy consumption. Science of The Total Environment, 679, 337–345. https://doi.org/10.1016/j.scitotenv.2019.05.011

Nathaniel, S. P., Murshed, M., & Bassim, M. (2021). The nexus between economic growth, energy use, international trade and ecological footprints: the role of environmental regulations in N11 countries. Energy, Ecology and Environment, 6(6), 496–512. https://doi.org/10.1007/s40974-020-00205-y

Nathaniel, S., Nwodo, O., Adediran, A., et al. (2019). Ecological footprint, urbanization, and energy consumption in South Africa: including the excluded. Environmental Science and Pollution Research, 26(26), 27168–27179. https://doi.org/10.1007/s11356-019-05924-2

O’Neill, B. C., Ren, X., Jiang, L., et al. (2012). The effect of urbanization on energy use in India and China in the iPETS model. Energy Economics, 34, S339–S345. https://doi.org/10.1016/j.eneco.2012.04.004

Ohlan, R. (2016). Renewable and nonrenewable energy consumption and economic growth in India. Energy Sources, Part B: Economics, Planning, and Policy, 11(11), 1050–1054. https://doi.org/10.1080/15567249.2016.1190801

Ouyang, Y., & Li, P. (2018). On the nexus of financial development, economic growth, and energy consumption in China: New perspective from a GMM panel VAR approach. Energy Economics, 71, 238–252. https://doi.org/10.1016/j.eneco.2018.02.015

Ozcan, B., & Ozturk, I. (2019). Renewable energy consumption-economic growth nexus in emerging countries: A bootstrap panel causality test. Renewable and Sustainable Energy Reviews, 104, 30–37. https://doi.org/10.1016/j.rser.2019.01.020

Ozcan, B., Tzeremes, P. G., & Tzeremes, N. G. (2020). Energy consumption, economic growth and environmental degradation in OECD countries. Economic Modelling, 84, 203–213. https://doi.org/10.1016/j.econmod.2019.04.010

Pachiyappan, D., Ansari, Y., Alam, M. S., et al. (2021). Short and Long-Run Causal Effects of CO_2 Emissions, Energy Use, GDP and Population Growth: Evidence from India Using the ARDL and VECM Approaches. Energies, 14(24), 8333. https://doi.org/10.3390/en14248333

Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. Renewable and Sustainable Energy Reviews, 15(3), 1513–1524. https://doi.org/10.1016/j.rser.2010.11.037

Parsa, H., & Sajjadi, S. Z. (2017). Exploring the Trade Openness, Energy Consumption and Economic Growth Relationship in Iran by Bayer and Hanck Combined Cointegration and Causality Analysis. Iranian Economic Review, 21(4), 829-845.

Pata, U. K., & Caglar, A. E. (2021). Investigating the EKC hypothesis with renewable energy consumption, human capital, globalization and trade openness for China: Evidence from augmented ARDL approach with a structural break. Energy, 216, 119220. https://doi.org/10.1016/j.energy.2020.119220

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

Ponce, P., Abdul, S., & Khan, R. (2021). A causal link between renewable energy, energy efficiency, property rights, and CO_2 emissions in developed countries: A road map for environmental sustainability. Environmental Science and Pollution Research, 28, 37804–37817. https://doi.org/10.1007/s11356-021-12465-0

Poumanyvong, P., Kaneko, S., & Dhakal, S. (2012). Impacts of urbanization on national transport and road energy use: Evidence from low, middle and high income countries. Energy Policy, 46, 268–277. https://doi.org/10.1016/j.enpol.2012.03.059

Prince Nathaniel, S., Alam, M. S., Murshed, M., et al. (2021). The roles of nuclear energy, renewable energy, and economic growth in the abatement of carbon dioxide emissions in the G7 countries. Environmental Science and Pollution Research, 28, 47957–47972. https://doi.org/10.1007/s11356-021-13728-6

Rafei, M., Esmaeili, P., & Balsalobre-Lorente, D. (2022). A step towards environmental mitigation: How do economic complexity and natural resources matter? Focusing on different institutional quality level countries. Resources Policy, 78, 102848. https://doi.org/10.1016/j.resourpol.2022.102848

Rahman, M. M., & Velayutham, E. (2020). Renewable and non-renewable energy consumption-economic growth nexus: New evidence from South Asia. Renewable Energy, 147, 399–408. https://doi.org/10.1016/j.renene.2019.09.007

Rahman, M. M., Alam, K., & Velayutham, E. (2022). Reduction of CO_2 emissions: The role of renewable energy, technological innovation and export quality. Energy Reports, 8, 2793–2805. https://doi.org/10.1016/j.egyr.2022.01.200

Rej, S., Bandyopadhyay, A., Mahmood, H., et al. (2022). The role of liquefied petroleum gas in decarbonizing India: fresh evidence from wavelet–partial wavelet coherence approach. Environmental Science and Pollution Research, 29(24), 35862–35883. https://doi.org/10.1007/s11356-021-17471-w

Sadorsky, P. (2012). Energy consumption, output and trade in South America. Energy Economics, 34(2), 476–488. https://doi.org/10.1016/j.eneco.2011.12.008

Sadorsky, P. (2014). The Effect of Urbanization and Industrialization on Energy Use in Emerging Economies: Implications for Sustainable Development. The American Journal of Economics and Sociology, 73(2), 392–409. https://doi.org/10.1111/ajes.12072

Salahuddin, M., Alam, K., Ozturk, I., et al. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait. Renewable and Sustainable Energy Reviews, 81, 2002–2010. https://doi.org/10.1016/j.rser.2017.06.009

Salahuddin, M., Habib, M. A., Al-Mulali, U., et al. (2020). Renewable energy and environmental quality: A second-generation panel evidence from the Sub Saharan Africa (SSA) countries. Environmental Research, 191, 110094. https://doi.org/10.1016/j.envres.2020.110094

Salari, M., Javid, R. J., & Noghanibehambari, H. (2021). The nexus between CO_2 emissions, energy consumption, and economic growth in the U.S. Economic Analysis and Policy, 69, 182–194. https://doi.org/10.1016/j.eap.2020.12.007

Samour, A., Baskaya, M. M., & Tursoy, T. (2022). The Impact of Financial Development and FDI on Renewable Energy in the UAE: A Path towards Sustainable Development. Sustainability, 14(3), 1208. https://doi.org/10.3390/su14031208

Sevillano, M. C., & Jareño, F. (2017). The impact of international factors on Spanish company returns: a quantile regression approach. Risk Management, 20(1), 51–76. https://doi.org/10.1057/s41283-017-0027-7

Shahbaz, M., Hoang, T. H. V., Mahalik, M. K., et al. (2017). Energy consumption, financial development and economic growth in India: New evidence from a nonlinear and asymmetric analysis. Energy Economics, 63, 199–212. https://doi.org/10.1016/j.eneco.2017.01.023

Shahbaz, M., Nasreen, S., Ling, C. H., et al. (2014). Causality between trade openness and energy consumption: What causes what in high, middle and low income countries. Energy Policy, 70, 126–143. https://doi.org/10.1016/j.enpol.2014.03.029

Shakib, M., Yumei, H., Rauf, A., et al. (2022). Revisiting the energy-economy-environment relationships for attaining environmental sustainability: evidence from Belt and Road Initiative countries. Environmental Science and Pollution Research, 29, 3808–3825. https://doi.org/10.1007/s11356-021-15860-9

Shastri, S., Mohapatra, G., & Giri, A. K. (2020). Economic growth, renewable and nonrenewable energy consumption nexus in India. International Journal of Energy Sector Management, 14(4), 777–792. https://doi.org/10.1108/ijesm-06-2019-0016

Ślusarczyk, B., Żegleń, P., Kluczek, A., et al. (2022). The Impact of Renewable Energy Sources on the Economic Growth of Poland and Sweden Considering COVID-19 Times. Energies, 15(1), 332. https://doi.org/10.3390/en15010332

Su, C. W., Xie, Y., Shahab, S., et al. (2021). Towards Achieving Sustainable Development: Role of Technology Innovation, Technology Adoption and CO_2 Emission for BRICS. International Journal of Environmental Research and Public Health, 18(1), 277. https://doi.org/10.3390/ijerph18010277

Suki, N. M., Suki, N. M., Sharif, A., et al. (2022). The role of technology innovation and renewable energy in reducing environmental degradation in Malaysia: A step towards sustainable environment. Renewable Energy, 182, 245–253. https://doi.org/10.1016/j.renene.2021.10.007

Tugcu, C. T., & Tiwari, A. K. (2016). Does renewable and/or non-renewable energy consumption matter for total factor productivity (TFP) growth? Evidence from the BRICS. Renewable and Sustainable Energy Reviews, 65, 610–616. https://doi.org/10.1016/j.rser.2016.07.016

Ullah, I., Ali, S., Shah, M. H., et al. (2019). Linkages between Trade, CO_2 Emissions and Healthcare Spending in China. International Journal of Environmental Research and Public Health, 16(21), 4298. https://doi.org/10.3390/ijerph16214298

UNPD. (2007). World Urbanization Prospects the 2007 revision population database. Available online: https://population.un.org/wup/ (accessed on 15 October 2018).

Usman, M., Balsalobre-Lorente, D., Jahanger, A., et al. (2022). Pollution concern during globalization mode in financially resource-rich countries: Do financial development, natural resources, and renewable energy consumption matter? Renewable Energy, 183, 90–102. https://doi.org/10.1016/j.renene.2021.10.067

Viardot, E. (2013). The role of cooperatives in overcoming the barriers to adoption of renewable energy. Energy Policy, 63, 756–764. https://doi.org/10.1016/j.enpol.2013.08.034

Vural, G. (2020). How do output, trade, renewable energy and non-renewable energy impact carbon emissions in selected Sub-Saharan African Countries? Resources Policy, 69, 101840. https://doi.org/10.1016/j.resourpol.2020.101840

Wang, Q., & Dong, Z. (2021). Does financial development promote renewable energy? Evidence of G20 economies. Environmental Science and Pollution Research, 28, 64461–64474. https://doi.org/10.1007/s11356-021-15597-5

Wang, X., Liang, S., Wang, H., et al. (2022). Do Fossil-Fuel Price Distortions Impact the Low-Carbon Transition in China's Energy Intensive Industries? Frontiers in Energy Research, 9. https://doi.org/10.3389/fenrg.2021.805224

Wurgler, J. (2000). Financial markets and the allocation of capital. Journal of financial economics, 58(1–2), 187–214. https://doi.org/10.1016/S0304-405X(00)00070-2

Ye, L., Cheng, Z., Wang, Q., et al. (2013). Overview on Green Building Label in China. Renewable Energy, 53, 220–229. https://doi.org/10.1016/j.renene.2012.11.022

Zaman, K. A. U., & Kalirajan, K. (2019). Strengthening of energy security & low-carbon growth in Asia: Role of regional energy cooperation through trade. Energy Policy, 133, 110873. https://doi.org/10.1016/j.enpol.2019.07.009

Zeren, F., & Akkuş, H. T. (2020). The relationship between renewable energy consumption and trade openness: New evidence from emerging economies. Renewable Energy, 147, 322–329. https://doi.org/10.1016/j.renene.2019.09.006

Zhang, C., & Lin, Y. (2012). Panel estimation for urbanization, energy consumption and CO_2 emissions: A regional analysis in China. Energy Policy, 49, 488–498. https://doi.org/10.1016/j.enpol.2012.06.048

Zhang, X., & Zhang, X. (2021). Nexus among economic growth, carbon emissions, and renewable and non-renewable energy in China. Environmental Science and Pollution Research, 28, 39708–39722. https://doi.org/10.1007/s11356-021-13218-9

Zhe, L., Yüksel, S., Dinçer, H., et al. (2021). The Positive Influences of Renewable Energy Consumption on Financial Development and Economic Growth. SAGE Open, 11(3), 215824402110401. https://doi.org/10.1177/21582440211040133

Zhou, N., Levine, M. D., & Price, L. (2010). Overview of current energy-efficiency policies in China. Energy Policy, 38(11), 6439–6452. https://doi.org/10.1016/j.enpol.2009.08.015

Zhou, W., Zhu, B., Chen, D., et al. (2011). Energy consumption patterns in the process of China's urbanization. Population and Environment, 33(2–3), 202–220. https://doi.org/10.1007/s11111-011-0133-5

Zivot, E., & Andrews, D. W. K. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. Journal of Business & Economic Statistics, 10(3), 251–270. https://doi.org/10.1080/07350015.1992.10509904