Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

Does green environmental policy promote renewable energy consumption in BRICST? Fresh insights from panel quantile regression

Xiaolong Li, Ilknur Ozturk, Qasim Raza Syed, Muhammad Hafeez & Sidra Sohail

To cite this article: Xiaolong Li, Ilknur Ozturk, Qasim Raza Syed, Muhammad Hafeez & Sidra Sohail (2022) Does green environmental policy promote renewable energy consumption in BRICST? Fresh insights from panel quantile regression, Economic Research-Ekonomska Istraživanja, 35:1, 5807-5823, DOI: 10.1080/1331677X.2022.2038228

To link to this article: https://doi.org/10.1080/1331677X.2022.2038228

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2022, VOL. 35, NO. 1, 5807–5823
https://doi.org/10.1080/1331677X.2022.2038228

Routledge
Taylor & Francis Group

OPEN ACCESS
Check for updates

Does green environmental policy promote renewable energy consumption in BRICST? Fresh insights from panel quantile regression

Xiaolong Li[a], Ilknur Ozturk[b], Qasim Raza Syed[c], Muhammad Hafeez[d] and Sidra Sohail[e]

[a]School of Modern Post, Beijing University of Posts and Telecommunications, Beijing, China; [b]Higher Vocational School, Cag University, Mersin, Turkey; [c]Ministry of Commerce, National Tariff Commission, Islamabad, Pakistan; [d]Faculty of Management & Administrative Sciences (FMAS), University of Sialkot, Sialkot, Pakistan; [e]Pakistan Institute of Development Economics (PIDE), Islamabad, Pakistan

ABSTRACT

Understanding the aspects of renewable energy consumption is important because it contains low-carbon emissions, which could significantly reduce global greenhouse gas emissions. Little research is done on exploring the factors of renewable energy consumption. The primary objective of this study is to examine the impact of the green environmental policy on renewable energy consumption in the BRICST economies over data ranging from 1991 and 2019 by using panel quantile regression. The fixed-effects and quantile regressions confirm the positive effects of economic growth and non-renewable energy on renewable energy consumption. In contrast, the consumer price index and CO_2 hurt the renewable energy consumption in the BRICST economies. The estimate of the environmental policy stringency appears to be negative and insignificant in the fixed-effects model. On the other side, the estimates of the environmental stringency index appear to be positively significant from the 10th–40th quantiles and negatively significant from 50th–90th quantiles. Robust policy implications of our outcomes are also discussed.

ARTICLE HISTORY
Received 23 September 2021
Accepted 1 February 2022

KEYWORDS
Environmental stringency policies; renewable energy consumption; BRICST

JEL CODES
E60; P18; Q20

1. Introduction

Since the outset of the industrial revolution, anthropogenic activities have been on the rise and wreaking havoc on the environment due to large-scale greenhouse gasses (GHG) emissions. The share of carbon is more than half of the GHG emissions and is considered a most potent threat to the environment and the existence of mankind on the earth. CO_2 causes environmental pollution and many other environmental problems such as rising global temperatures, glacier melting, floods, droughts, and

CONTACT Sidra Sohail sidrasohail_14@pide.edu.pk

sea storms (Danish et al., 2018). Since the past few decades, environmental deterioration in general and deteriorating air quality, in particular, has become the hot topic for most forums at the international level and is a crucial concern for world leaders and environmental policymakers. The first and foremost effect of environmental pollution comes in the form of health concerns for the inhabitants of the earth (Landrigan et al., 2018). The harmful effects of environmental pollution on human health can be recognized by the fact that in 2013, 1 out of 10 or in total 5.5 million premature deaths were connected to deteriorating air quality (World Bank, 2016). And the same report has projected that there will be 6–9 million premature deaths annually by the end of 2060 (World Bank, 2016). However, most of the pollution-connected deaths, i.e., almost 92% of the deaths, are recorded in low and middle-income nations. On the material front, the pollution-related productivity losses have been registered as a 2% of the GDP annually in the middle and low-income countries (Landrigan et al., 2018). On the other side, the international panel on climate change (IPCC, 2018) highlighted the potential threats attached to the degradation of environmental quality by saying that if the CO_2 emissions are kept on rising at the same pace, it may lead the world towards more severe environmental problems very soon. Therefore, sustainable development, i.e., protecting the environment without compromising on the goal of economic growth, is the most pertinent challenge faced by the world these days (Costa-Campi et al., 2017; Landrigan et al., 2018). Consistent with this opinion, many researchers and empirics have tried to examine the various factors that can help to achieve sustainable development, and among them, the most prominent is renewable energy consumption (Bilgili et al., 2016; Sadorsky, 2009) and more recently environment policy stringency (Ahmed & Ahmed, 2018; Wang et al., 2020; Wolde-Rufael & Weldemeskel, 2020).

Environmental degradation has posed severe threats for human beings. As a result, the demand for environmental policy stringency and renewable energy projects also increases because both renewable energy projects and the strictness in environmental-related rules and regulations are necessary to promote environmental sustainability. The main objective of the environment-related rules and regulations is to attain a green environment without hampering the growth target. Therefore, the imposition of strict rules and regulations regarding the environment and deployment of renewable energy plants instead of dirty energy projects have become the cornerstone of environmental policy in many developing and emerging economies, and BRICST (Brazil, Russia, India, China, South Africa, and Turkey) economies are no exceptions (Pinto et al., 2018; Taylor et al., 2012). Recently, some researchers have started to include environmental policy stringency as a potential candidate that can successfully curb CO_2 emissions, but none have particularly focused on the BRICST economies (Ouyang et al., 2020; Mardani et al., 2019). The time has now arrived where instead of macro-economic variables, the environmentalists and empirics should focus on the environmental policy stringency as a potential determinant of CO_2 emissions and renewable energy (Khan et al., 2019).

Given the role of renewable energy to achieve sustainable development, the deployment of renewable energy projects has become a national agenda in many advanced and high-income economies. Since the 1980s, due to the unstable nature of oil prices, many developed economies have started to rely heavily on green energy sources such as wind, solar, biofuels, and hydel. Thus, green and renewable energy has emerged as an alternative to traditional sources of energy, which are mainly dependent on oil and other fossil fuels. Since the 1990s, due to the environmentally friendly nature of renewable energies, they have also become part and parcel of action strategies worldwide that focus on environmental degradation and climate change (Gan et al., 2007). Given the importance of renewable energies in maintaining a cleaner and greener environment and without compromising on economic growth targets, renewable and clean energy has also been included in the proposed sustainable development goals of the United Nations in 2015. On one side, a rise in the share of renewable energy in the energy mix over the past few decades has improved energy security in many advanced economies. On the other side, renewable energy sources have become a permanent part of the national efforts to achieve long term environmental sustainability (Carley, 2009; Marques & Fuinhas, 2012). Encouraged by this growing significance, the installment of clean energy projects has gained extraordinary growth in recent years. A report published by the international energy agency (IEA, 2010) highlighted that from 2000–2010, the deployment of renewable energy projects has increased by a massive amount of 165.4%.

Against this backdrop, it is very pertinent to determine the factors that lead to the promotion or demotion of renewable energy projects. Apart from the volatile nature of oil prices, issues of energy security, and environmental protection, various policy variables cause renewable energy projects to rise. For instance, providing easy access to credit facilities for renewable energy projects, tax rebates for renewable energy systems, and the development of markets that offer certificates for renewable energy are essential in promoting the share of renewable energy in the energy mix (Bashir et al., 2021; Bowden & Payne, 2010). However, some policies such as environmental policy stringency that are implemented with an aim to protect the environment may also promote, first, renewable energy production and then its consumption.

As already discussed, some studies have recently included environmental policy stringency into the carbon emission function of various countries; however, none of the studies in the past have focused on whether the environmental policy stringency will lead to an upsurge in renewable energy ventures. Because most of the environment stringency policies demand the firms and businesses to increase the use of renewable energy in their manufacturing and managerial process (Zhang et al., 2020). Environmental policy stringency struggles to encourage sustainable growth by controlling its adverse external effects such as environmental pollution to stimulate green invention (Zhang et al., 2020). Other policies such as environmental taxes and increased use of renewable energy cannot provide desired results unless supported by the imposition of stringency in environmental policy (Taylor et al., 2012). The environmental stringency index made it possible to distinguish how the target of alleviating CO_2 productions, encouraging renewable energy, and preserving the justifiable environment are being attained.

Regarding sample selection, the study has adopted BRICST economies. In 2015, BRICS economies accounted for 41 percent share of CO_2 emissions in the total combustion of worldwide CO_2 emissions (). Additionally, BRICS countries are a new emerging powerhouse of economic gravity globally. BRICS economies are although composed of 40 percent of the world's population but these economies share almost 21 percent GDP of the world and consume approximately 40 percent of the total world's energy (Zhao et al., 2021). Therefore, in this study, we have aimed to examine the role of environmental policy stringency in promoting renewable energy consumption. This is the first-ever study that has tried to find the role of the environmental stringency index in encouraging BRICST renewable energy consumption. The BRICST nations are essential since they decided to manage their environmental rules according to the Paris climate accord. They affirmed to address the mutual challenges with partnership in the 10th Conference in Johannesburg, South Africa, 2018.

The rest of the study is prepared in the following way. In next section, we reported literature review. Section 3 provides data, material, and methods. In Sec. 4, we discuss the results, and conclusion in Sec. 5.

2. Literature review

Existing industrialization processes profoundly depend upon the consumption of fossil fuels because economic development is directly and indirectly linked with energy demand. In this premise, renewable energy consumption appeared as a substitute for fossil fuel energy sources. It is believed that the adoption of renewable energy consumption sources is a real approach that can overcome the issues of environmental degradation (Lei et al., 2021). This study is exploring the current literature regarding environmental policy and renewable energy consumption nexus. One strand of literature is digging into the effect of environmental taxes and environmental regulations on renewable energy. Environmental taxes are imposed to shape the patterns of energy consumption for both economic growth and environmental sustainability (Bashir et al., 2021). Ding et al. (2019) explored that environmental technologies and environmental taxes reduce CO_2 emissions in highly polluted countries. Carrera et al. (2015) reveal that environmental taxes bring positive effects on the economy and environment. Pang et al. (2019) considered environmental tax as an instrument of energy policy and reported that environmental tax reduces CO_2 emissions and enhances the efficiency of energy.

Another group of researchers argued that the exact effect of environmental policies depends upon the structure of economic sectors. The study of Rapanos and Polemis (2005) denoted that environmental taxes result in reducing CO_2 emissions and reported that better environmental outcomes could be obtained if different environmental policies are chosen for different economies. Mardones and Baeza (2018) reported that environmental tax of high magnitude can lower CO_2 emissions in South American economies. Allan et al. (2014) studies reported that environmental regulations and clean energy consumption can enhance environmental sustainability significantly. Some studies report that CO_2 emissions cause a reduction in economic development (Usman et al., 2021; Ullah et al., 2021).

In literature, a bulk of literature takes into consideration the effect of environmental policies on various aspects of renewable energy sources (Bourcet, 2020; Fotis &

Polemis, 2018; Omri & Nguyen, 2014; Sohail et al., 2021). Regarding the role of environmental policies in encouraging renewable energy consumption, studies provide mixed findings, depending on the analyzed countries and period, as well as renewable energy sources and types of environmental policies. Various researchers argued that the implementation of clean environmental policies can promote renewable energy consumption (Lei et al., 2021). Acemoglu et al. (2016) explored the association between eco-friendly taxes and carbon emissions and concluded that environmental regulations tend to mitigate CO_2 emissions and upsurge the need for renewable energy sources for a clean environment. Menz and Vachon (2006) investigated the impact of five environmental policy instruments on wind energy in the case of 39 states of the USA. The study found that only two policy instruments report a significant and positive impact on wind energy. Bersalli et al. (2020) study reported that environmental taxes are proved to be insignificant in boosting investment for renewable energy sources in the sample of Latin American economies. Johnstone et al. (2012) investigate the effect of several tools of environmental policy on technological innovations and renewable energy sources. The study reported that the effectiveness of environmental instruments depends upon the nature of renewable energy sources. In contrast, more environmental tax-related subsidies are required to stimulate technological innovation in the renewable energy sector.

Existing studies have focused on renewable portfolio standards and feed-in-tariffs as determinants of environmental policy (Alizada, 2018). To the best of the authors' knowledge, the effect of environmental policy on renewable energy consumption has not been explored yet. Yin and Powers (2010) explored the impact of renewable portfolio standard policy on renewable energy sector capacity for fifty states of the USA. The findings report that the high implication of renewable portfolio standard policy promotes renewable energy sector development. However, Ullah and Ozturk (2020) explored the impact of renewable portfolio standard policy on the development of renewable energy sources market. The study implies that portfolio standard policy increases the extent of renewable energy in solar generation, electricity generation mix, and renewable energy capacity. Jenner et al. (2013) explored the environmental stringency policy impact on renewable energy wholesale price and cost. The findings reveal that environmental stringency policy is effective in boosting renewable energy capacity growth. Very little research is done on the nexus of environmental policies and renewable energy consumption.

3. Model, methods, and data

We discuss the economic/empirical model in this section. It is worth reporting that there exist two stances of literature about the economic/empirical model. One stance adopts the determinants (variables) of renewable energy that have been employed in the prior literature. While the other stance employs the neoclassical demand function, explaining that demand for a product is the function of income and price. This study also adopts the neoclassical demand function since it has an economic foundation. Several studies employ the neoclassical demand function while modeling the determinants of renewable energy consumption (see, for example, Dogan et al., 2021). This research work is performed under a theoretical framework of the green growth paradox, which is pioneered by Sinn (2008). The basic model is:

$$REN_{it} = \emptyset_0 + \emptyset_1 GDP_{it} + \emptyset_2\ CPI_{it} + \emptyset_3\ CO_{2,\ it} + \emptyset_4\ ENE_{it} + \emptyset_5\ ESI_{it} + \in_{it} \quad (1)$$

Equation (1) shows an extended neoclassical demand function that reports determinants of renewable energy. Next, REN, GDP, CPI, CO_2, ENE, and ESI is renewable energy consumption, GDP per capita, consumer price index, carbon dioxide per capita, non-renewable energy consumption, and environmental stringency index, respectively. Moreover, i is a cross-section (country), t is time, and $\in$ is the error term. Also, $\emptyset_j$ (j = 0, 1, 2, 3, 4, 5) is estimator/coefficient.

It is worth mentioning that GDP, CPI, and ENE are the economic determinants, while CO_2 and ESI are the environmental determinants of renewable energy. The expected sign of the coefficient of GDP is positive, indicating that economic growth leads to higher renewable energy consumption (Inglesi-Lotz, 2016). However, the expected sign of CPI and ENE is negative, highlighting that higher inflation and non-renewable energy mitigate renewable energy use (Sadorsky, 2010). Parallel to this, the envisaged sign for CO_2 is negative, reporting that higher carbon emissions indicate that the share of renewable energy in the energy mix has been decreasing (Dogan et al., 2021). Finally, the predicted sign for ESI is positive, explaining that strict environmental measures propel renewable energy consumption.

In this study, we have employed two advanced estimation techniques that overcome the autocorrelation and endogeneity problems. Both FMOLS and DOLS are robust estimation techniques and provide efficient results in a problem of cross-sectional dependence. The FMOLS and DOLS methods focus on mean effects, which cannot show the heterogeneous impact of environmental policy on renewable energy consumption across the different distributions. Therefore, along with FMOLS and DOLS estimators, panel quantile regression with fixed effects is also applied. This approach provides different coefficient estimates at different quantiles. Another benefit is that the panel quantile approach does not follow a normal distribution in estimation (Bera et al., 2016; Zhu et al., 2016).

This study explores the impact of environmental stringency policies on renewable energy consumption in the BRICST (Brazil Russia, India, China, South Africa, Turkey) economies by using the data over 1991–2019. Existing studies explored the impact of CO_2 emissions, oil prices, GDP per capita, CO_2 emissions, and trade on renewable energy demand (Omri & Nguyen, 2014; Bourcet, 2020). Based on standard literature, our study also explores the importance of environmental policy on renewable energy consumption by controlling macroeconomic variables. The dependent variable is renewable energy consumption (REN), measured by the share of renewables in the energy mix. The key independent variable is the environmental stringency index (ESI). Moreover, GDP per capita (constant 2010$), consumer price index (CPI), and CO_2 emissions per capita (metric ton per capita) are the control variables. Additionally, all dataset is transformed into natural logarithmic form to avoid heteroscedasticity and to report meaningful interpretation of results. The data of environmental policy stringency is taken from OECD, but remaining all variables have been taken from World Bank.

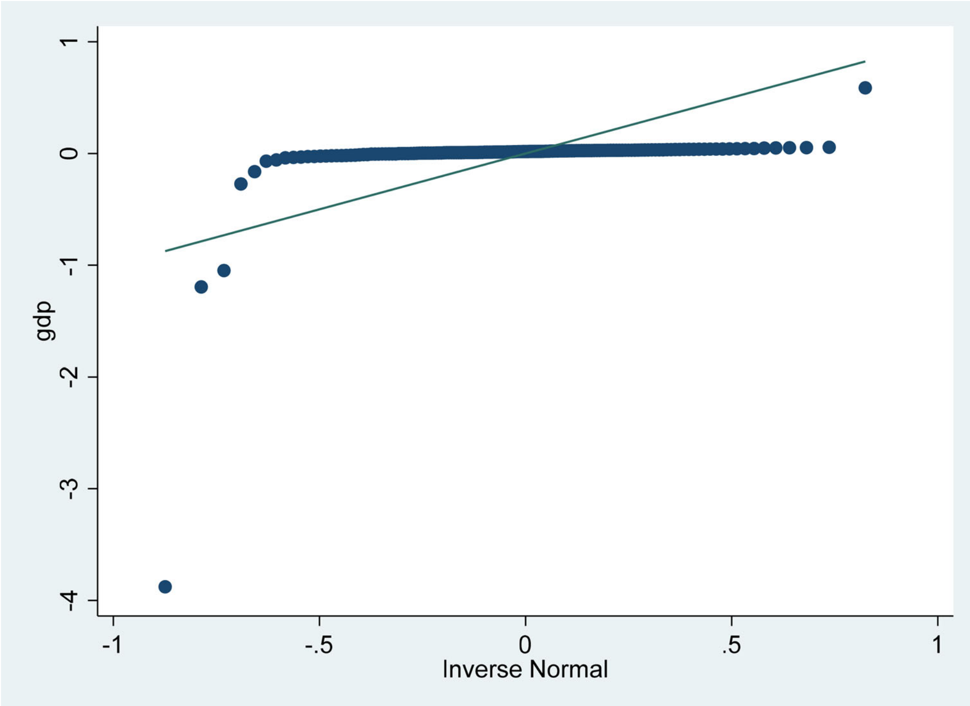

Figure 1. Q-Q plot of GDP.
Source: Author's own calculations.

Additionally, we provide the Q-Q plots that depict the graphical representation for normality of the data in Figures 1–6. In the Q-Q plot, the deviation of the blue dotted line from the diagonal line shows that data do not follow the normal distribution. It is worth reporting that all variables follow non-normal distribution in the present study. The scrutiny for normal distribution is crucial for several reasons. For instance, mean-based regression methodologies assume that data follow the normal distribution, and these methodologies may provide biased outcomes in the existence of non-normal distribution. Contrary to this, quantile-based regressions provide unbiased and robust outcomes even the data is non-normally distributed. The non-normal distribution of selected variables of this study propels us to employ a quantile-based regression approach.

4. Empirical findings

This section reports the findings from cross-sectional dependence tests, second-generation unit root tests, second-generation co-integration test, and panel quantile regression for comprehensive and robust outcomes. We employ Pesaran cross-sectional dependence (CD) test, Frees CD test, and Friedman CD test in this analysis. Table 1 is rejected the null hypothesis. Hence, it could be concluded that there exists CD in our analysis. Cross-sectional dependence occurs due to unobserved shocks in renewable energy consumption in BRICST economies. Next, the unit root is also a critical issue in panel data, which may cause misleading findings. In the prior literature,

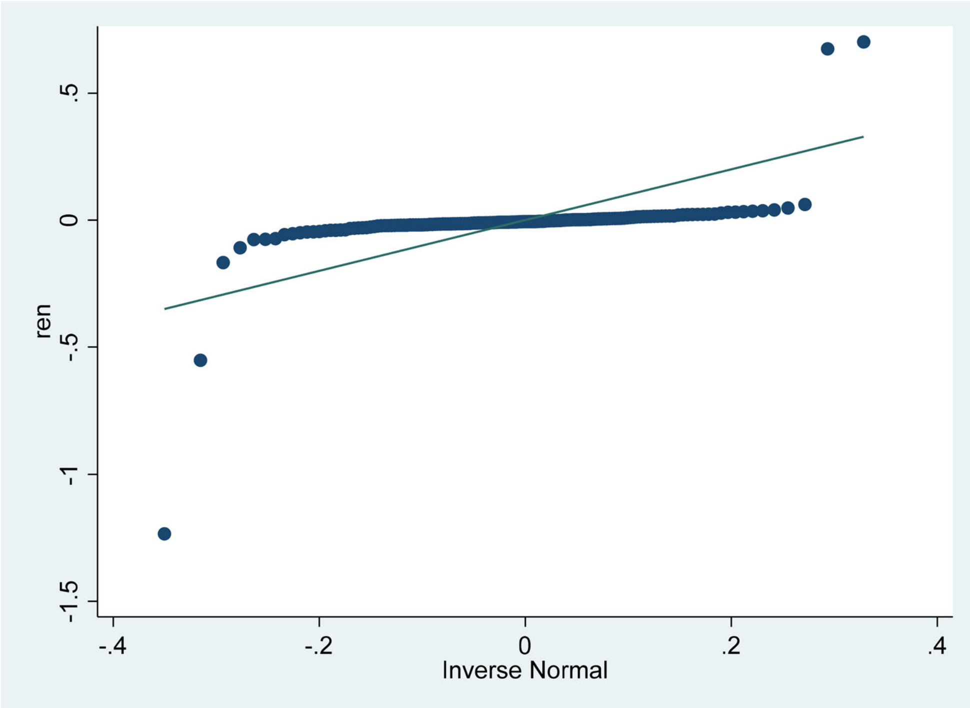

Figure 2. Q-Q plot of REN.
Source: Author's own calculations.

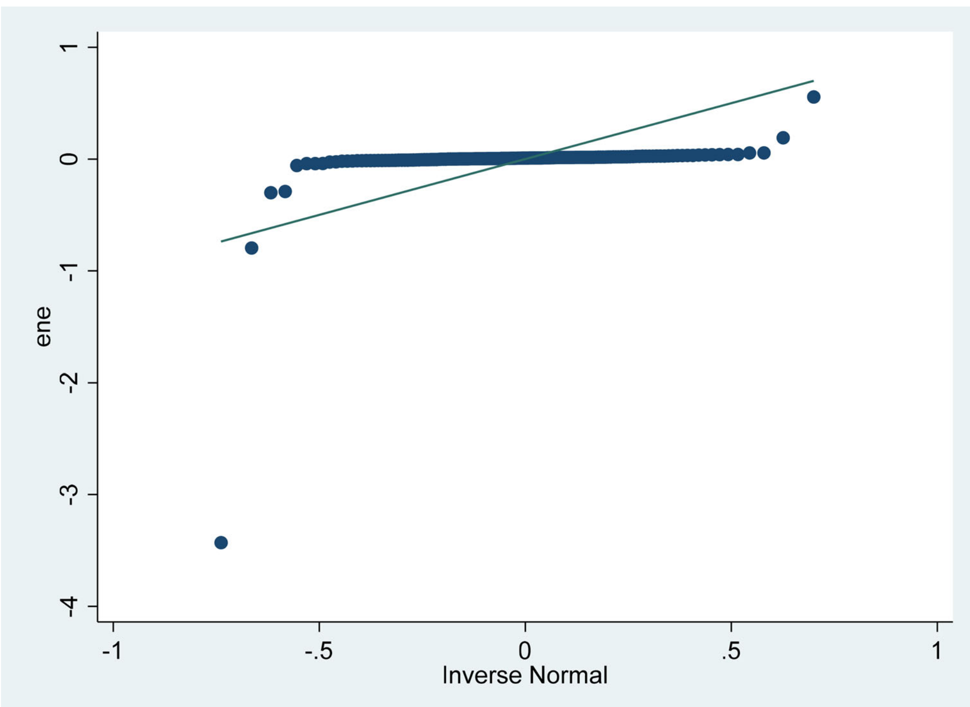

Figure 3. Q-Q plot of ENE.
Source: Author's own calculations.

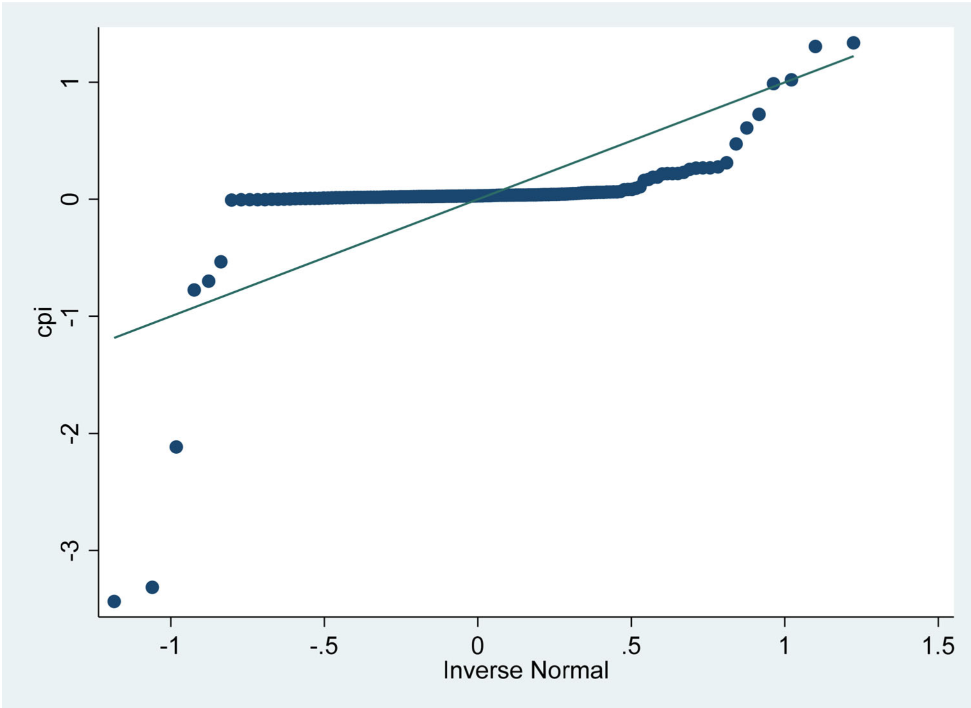

Figure 4. Q-Q plot of CPI.
Source: Author's own calculations.

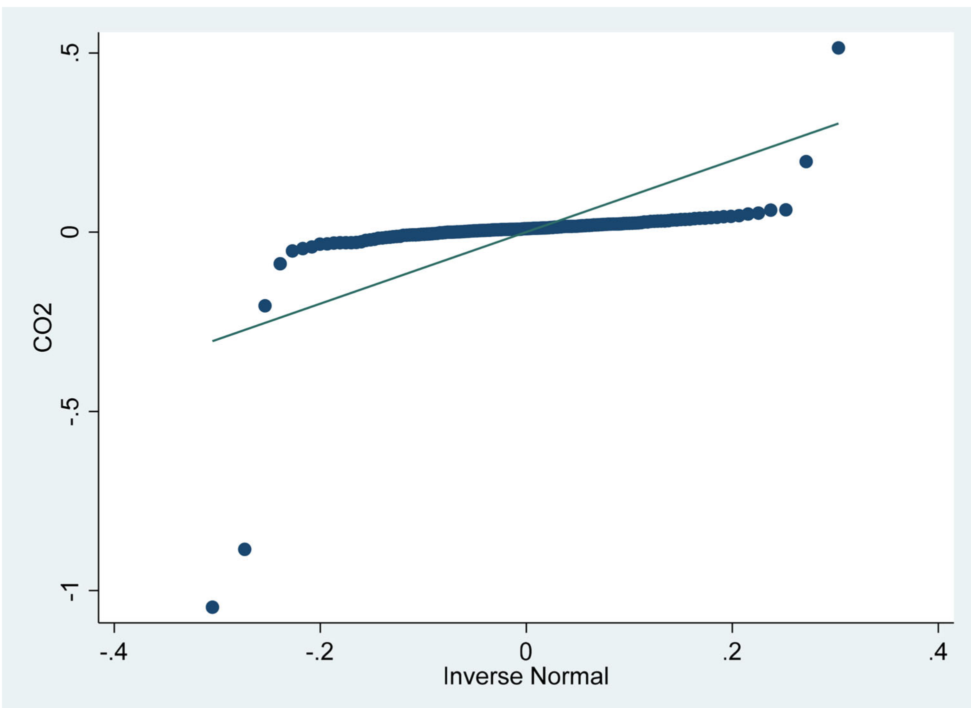

Figure 5. Q-Q plot of CO_2.
Source: Author's own calculations.

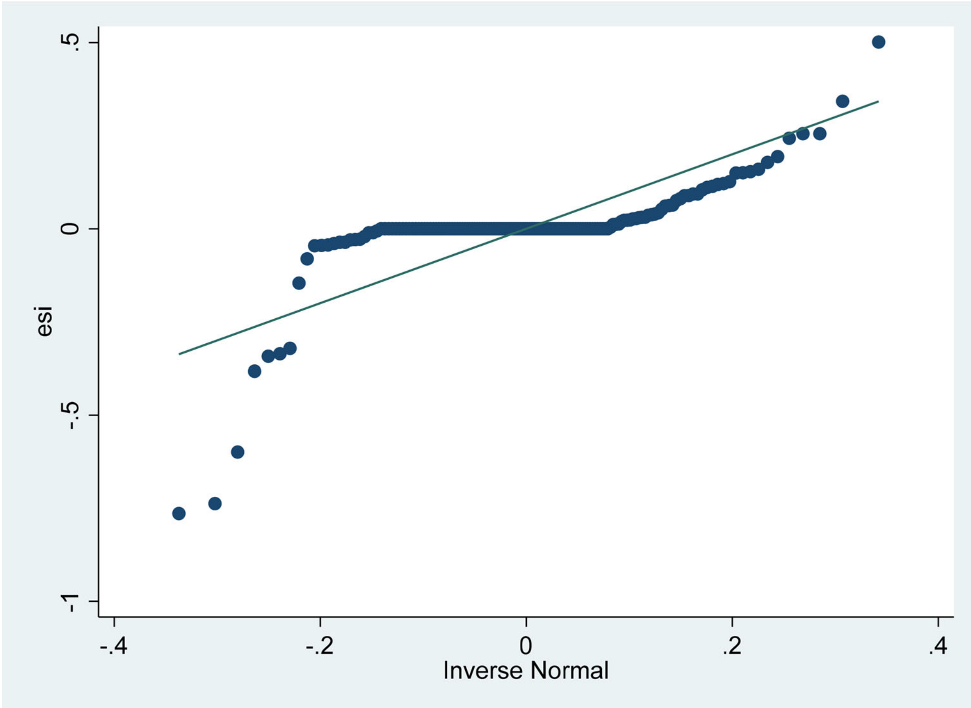

Figure 6. Q-Q plot of ESI.
Source: Author's own calculations.

Table 1. Cross-sectional dependence test.

	Pesaran CD test	Friedman test	Frees test
REN = f(GDP, ENE, CPI, CO_2, ESI)	(10.07)***	(12.00)***	(14.02)**

Note: ***$p < 0.01$ and **$p < 0.05$.
Source: Author's own calculations.

Table 2. Unit root testing.

	CIPS test		CADF test	
	I(0)	I(1)	I(0)	I(1)
CO_2	−2.025	−2.889***	−2.132	−3.312***
GDP	−1.925	−2.903***	−1.925	−3.775***
REN	−2.021	−3.464***	−2.065	−2.633***
ENE	−2.325	−3.212***	−2.454	−4.142***
ESI	−0.289	−2.725***	−1.472	−3.924***

Note: *** represents the level of sig. at 1%.
Source: Author's own calculations.

various unit root testing approaches have been used. The null hypothesis of CIPS and CADF test is that there exists unit root. In Table 2, we could not reject the null hypothesis from both tests at the level. This implies that there is a unit root at the level and series become stationary at the first difference.

Further, there are several panel co-integration tests in the previous literature. However, these tests could be divided into first- and second-generation co-integration tests. Like first-generation unit root tests, first-generation co-integration tests (e.g.,

Table 3. Results from Westerlund (2007) test.

Statistic	Value	*p*-value
Gt	−13.01***	0.00
Ga	−6.322***	0.00
Pt	−12.83***	0.00
Pa	−14.07***	0.00

Note: ***$p < 0.01$.
Source: Author's own calculations.

Table 4. Results of FMOLS and DOLS.

	FMOLS			DOLS		
	Coef.	S.E	t-stat	Coef.	S.E	t-stat
GDP	0.183***	0.050	3.660	0.181***	0.052	3.520
ENE	0.467***	0.069	6.620	0.440***	0.070	6.590
CPI	0.020	0.014	1.440	0.016	0.014	1.130
CO_2	−1.279***	0.074	17.36	−1.261***	0.076	16.97
ESI	−0.054	0.048	1.120	−0.046	0.049	0.950

Note: ***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$.
Source: Author's own calculations.

Table 5. Fixed effects and quantile regression estimates.

	Fixed effects	Panel quantile regression								
		10th	20th	30th	40th	50th	60th	70th	80th	90th
GDP	0.18**	0.19***	0.18***	0.28***	0.23***	0.09***	0.04***	0.03***	0.04***	0.08***
ENE	0.45***	0.43***	0.45***	0.34***	0.40***	0.54***	0.60***	0.60***	0.64***	0.55***
CPI	0.01	0.02***	0.02***	0.01***	0.00***	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***
CO_2	−1.28***	−1.22***	−1.24***	−1.21***	−1.20***	−1.13***	−1.12***	−1.12***	−1.25***	−1.34***
ESI	−0.04	0.01***	0.04***	0.01***	0.01***	−0.01***	−0.02***	−0.01***	−0.01***	−0.01***

Note: ***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$.
Source: Author's own calculations.

Pedroni test and Kao test) do not account for the issue of CD. However, the second-generation test (e.g., Westerlund 2007, etc.) outperforms the first-generation test due to their ability to handle the CD. Hence, we employ Westerlund (2007) test based on its aforementioned merit. Table 3 reports the findings from Westerlund (2007) test and this implies that there is a long-run relationship among the selected variables.

. After confirming the long-run association among variables, the next step is to calculate the long-run coefficient estimates. The study explores the heterogeneous effects of environmental policy on renewable energy consumption through the quantiles approach. However, the study has also used DOLS and FMOLS approaches to calculate the long-run coefficient estimates for making a comparison. Table 4 reports the coefficient estimates of FMOLS and DOLS regressions. It can be seen that the results obtained from both methodologies are consistent. It implies that GDP reports a positive impact on renewable energy consumption in models, confirming that GDP growth promotes renewable energy consumption in BRICST economies. The findings report that total energy consumption contributed to significantly increasing renewable energy consumption in BRICST economies. However, CO_2 reports a negative impact on renewable energy consumption, revealing that an increase in CO_2 emissions causes a decline in renewable energy consumption. The findings display that CPI and ESI have an insignificant effect on renewable energy consumption in BRICST economies.

Finally, we present the findings from panel quantile regression coupled with the fixed effects model, for comparison purposes. Table 5 yields the findings from the fixed-effects model and the panel quantile regression model at 10th–90th quantile. Regarding the findings from the fixed-effects model, the coefficient of GDP is statistically significant and positive, indicating that economic growth leads to higher renewable energy consumption in the selected countries. Next, the coefficient of ENE is also positive, suggesting that non-renewable energy consumption compels the use of renewable energy consumption. Further, the coefficient of CPI is insignificant, reporting that inflation does not affect renewable energy consumption. On the contrary, the coefficient of CO_2 emissions is negative and statistically significant, which highlights that carbon emissions plunge the renewable energy consumption. Finally, the coefficient of ESI is statistically insignificant, explaining that environmental stringency policies do not affect renewable energy consumption.

The findings show that the coefficient of GDP is positive significant across the distribution. Sadorsky (2009) reveals that an upsurge in GDP per capita brings a significant and positive effect on renewable energy consumption. A similar finding is also reported by Salim and Rafiq (2012). This reports that economic growth leads to higher renewable energy consumption. In particular, the magnitude of the coefficient of GDP is relatively high at lower quantiles (i.e., 10th–40th), and it is relatively low at upper quantiles (i.e., 50th–90th). It suggests that economic growth plays a meager role to escalate renewable energy in countries with relatively low renewable energy consumption. On the contrary, economic growth plays a vital role to surge renewable energy in countries with higher rates of renewable energy consumption. These findings are somehow in line with the conclusion of Apergis and Payne (2012). The higher economic growth surges the income level, which, in turn, increases the preferences of individuals for a clean environment. Hence, the use of renewable energy rises since it plunges environmental degradation. Next, the coefficient of ENE is positive and statically significant at all quantiles, reporting that non-renewable energy surges the renewable energy consumption in the BRICST countries. The magnitude of ENE is relatively low at lower quantiles (i.e., 10th–40th), and it is relatively high at higher quantiles (i.e., 50th–90th). This implies that the use of non-renewable energy poses a relatively high impact on the growth of renewable energy in countries with higher rates of renewable energy consumption. This outcome is backed by the conclusion of Attiaoui et al. (2017). This means that renewable energy and crude oil are complements and cannot be substituted for consumption. It reveals that users of energy consume renewable energy and crude oil together. The growth in non-renewable energy consumption could be the signal for higher demand for energy consumption in the BRICST countries. To meet the higher energy demand, renewable energy consumption increases as well.

The coefficient of CPI is positive significant at lower quantiles (i.e., 10th–40th), nonetheless, it is negative and statistically significant for higher quantiles (i.e., 50th–90th). This indicates that inflation leads to higher renewable energy consumption at lower quantiles, while it discourages renewable energy consumption at higher quantiles. This outcome is somehow similar to the findings of Sadorsky (2010) and Dogan et al. (2021). Thus, at higher quantiles, there is a possibility that a decrease in purchasing power (i.e., due to high CPI) restraints individuals to consume renewable energy.

Interestingly, the coefficient of CO_2 emissions is negative and statistically significant across the distribution, reporting that high carbon emissions mitigate renewable energy consumption. This finding is backed by the conclusion of Attiaoui et al. (2017). Theoretical prediction implies a negative impact of environmental pressure on renewable energy consumption (Wang et al., 2020), but CO_2 emissions impedes clean energy consumption by increasing dirty energy consumption in the case of BRICS. A similar finding is also reported by Bourcet (2020). This also infers that BRICS economies trade-off between dirty and clean energy consumption for high economic growth. Finally, the coefficient of ESI is positive significant at lower quantiles, whilst it is negative significant at higher quantiles. This outcome is somehow in line with the findings of Yang (2021), who concludes that ESI has detrimental impacts on energy efficiency. This indicates that environmental stringency policies contribute to higher renewable energy consumption at lower quantiles (i.e., 10th–40th), whereas they impede the renewable energy consumption at higher quantiles (i.e., 50th–90th). At lower quantiles, environmental stringency policies are strictly being followed, and they are relatively austere. As a result, renewable energy consumption rises in countries with low renewable energy consumption. On the contrary, at higher quantiles (i.e., countries with higher renewable energy consumption), environmental stringency policies are lenient and not fully backed by the law, which, in turn, compels individuals to use non-renewable energy since it is relatively cheap. The findings are more sensitive to the use of panel quantile regression. Hence, lenient environmental stringency policies mitigate renewable energy consumption.

5. Conclusion and implications

Over the last few decades, anthropogenic activities have contributed a lot to environmental degradation. The biggest culprit in contaminating the environment is CO_2 emissions due to increased social and economic activities worldwide. Moreover, CO_2 emissions are the biggest hurdle in the way of sustainable development. Therefore, world leaders and environmental policymakers have emphasized the joint efforts to attain a better environment alongside long-term economic growth. Several empirics have tested various factors that can contribute to economic growth without damaging the environment by a great deal, and they have reached a consensus that renewable energy is the most important factor to attain sustainable development. However, the determinants of renewable energy are still underexplored, and this study is an effort to fill this gap in the literature.

The primary objective of this study is to investigate the impact of the environmental stringency index on renewable energy consumption in the BRICST economies over a time data span from 1991 to 2019. Some of the studies have recently included environmental policy stringency index in the carbon emission function of different countries and regions; but, none have considered it a potential determinant of renewable energy. Our analysis is based on the fixed-effects model and quantile regression estimation technique. The fixed and quantile regressions confirm the positive effects of GDP and ENE on renewable energy consumption. In contrast, the CPI and CO_2 hurt the renewable energy consumption in the BRICST economies. The estimate of the index of environmental policy stringency appears to be insignificant negative in the fixed-effects model. On the other side, the estimates of the environmental stringency index appear to be positively significant from the 10th–40th quantiles and negatively significant from 50th–90th quantiles. From these results, we can deduce that the environmental stringency index contributed positively to renewable energy consumption with low consumption of renewable energy and vice versa.

The analysis provides some policy advice for concerned stakeholders. In countries where renewable energy consumption is low, environmental policy stringency increases the demand for renewable energy. Hence, apart from other policy variables (e.g., credit facilities for renewable energy projects, tax rebates for installing renewable energy plants, and removing the procedural barriers in the deployment of renewable energy projects), policymakers should also focus on these dimension. Similarly, in the countries where renewable energy is already on the rise, a highly stringent environmental policy may negatively impact renewable energy consumption, increasing the CO_2 emissions in these countries. Therefore, the environmental stringency policy should be used prudently and cautiously.

Our study consists of the following shortcomings/limitations. Some important variables such as financial institution, financial markets development, democratic and institutional variables are ignored in empirical analysis. These variables should be added in future research. Future research can also observe the impact of the carbon tax, environmental regulation, and environmental stringency policy on renewable energy consumption. Future research can also explore the determinants of renewable energy sources for BRICST economies and other regional groups. Similar research can also be replicated for other regional groups, developed, and developing economies.

Disclosure statement

No potential conflict of interest was provided by the authors.

ORCID

Muhammad Hafeez http://orcid.org/0000-0001-7231-5413

References

Acemoglu, D., Akcigit, U., Hanley, D., & Kerr, W. (2016). Transition to clean technology. *Journal of Political Economy*, *124*(1), 52–104. https://doi.org/10.1086/684511

Ahmed, K., & Ahmed, S. (2018). A predictive analysis of CO_2 emissions, environmental policy stringency, and economic growth in. *Environmental Science and Pollution Research*, *25*(16), 16091–16100. https://doi.org/10.1007/s11356-018-1849-x

Alizada, K. (2018). Rethinking the diffusion of renewable energy policies: A global assessment of feed-in tariffs and renewable portfolio standards. *Energy Research & Social Science*, *44*, 346–361. https://doi.org/10.1016/j.erss.2018.05.033

Allan, G., Lecca, P., McGregor, P., & Swales, K. (2014). The economic and environmental impact of a carbon tax for Scotland: A computable general equilibrium analysis. *Ecological Economics*, *100*, 40–50. https://doi.org/10.1016/j.ecolecon.2014.01.012

Apergis, N., & Payne, J. E. (2012). Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. *Energy Economics*, *34*(3), 733–738. https://doi.org/10.1016/j.eneco.2011.04.007

Attiaoui, I., Toumi, H., Ammouri, B., & Gargouri, I. (2017). Causality links among renewable energy consumption, CO_2 emissions, and economic growth in Africa: Evidence from a panel ARDL-PMG approach. *Environmental Science and Pollution Research*, *24*(14), 13036–13048. https://doi.org/10.1007/s11356-017-8850-7

Bashir, M. F., Ma, B., Bashir, M. A., Radulescu, M., & Shahzad, U. (2021). Investigating the role of environmental taxes and regulations for renewable energy consumption: Evidence from developed economies. *Economic Research-Ekonomska Istraživanja*, 1–23. https://doi.org/10.1080/1331677X.2021.1962383

Bera, A. K., Galvao, A. F., Montes-Rojas, G. V., & Park, S. Y. (2016). Asymmetric laplace regression: Maximum likelihood, maximum entropy and quantile regression. *Journal of Econometric Methods*, *5*(1), 79–101. https://doi.org/10.1515/jem-2014-0018

Bersalli, G., Menanteau, P., & El-Methni, J. (2020). Renewable energy policy effectiveness: A panel data analysis across Europe and Latin America. *Renewable and Sustainable Energy Reviews*, *133*, 110351. https://doi.org/10.1016/j.rser.2020.110351

Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO_2 emissions: A revisited Environmental Kuznets Curve approach. *Renewable and Sustainable Energy Reviews*, *54*, 838–845. https://doi.org/10.1016/j.rser.2015.10.080

Bourcet, C. (2020). Empirical determinants of renewable energy deployment: A systematic literature review. *Energy Economics*, *85*, 104563. https://doi.org/10.1016/j.eneco.2019.104563

Bowden, N., & Payne, J. E. (2010). Sectoral analysis of the causal relationship between renewable and non-renewable energy consumption and real output in the US. *Energy Sources, Part B: Economics, Planning, and Policy*, *5*(4), 400–408. https://doi.org/10.1080/15567240802534250

Carley, S. (2009). State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy*, *37*(8), 3071–3081. https://doi.org/10.1016/j.enpol.2009.03.062

Carrera, L., Standardi, G., Bosello, F., & Mysiak, J. (2015). Assessing direct and indirect economic impacts of a flood event through the integration of spatial and computable general equilibrium modelling. *Environmental Modelling & Software*, *63*, 109–122. https://doi.org/10.1016/j.envsoft.2014.09.016

Costa-Campi, M. T., del Rio, P., & Trujillo-Baute, E. (2017). Trade-offs in energy and environmental policy.

Danish, Khan N., Baloch, M. A., Saud, S., & Fatima, T. (2018). The effect of ICT on CO2 emissions in emerging economies: does the level of income matters?. *Environmental Science and Pollution Research*, *25*(23), 22850–22860.

Ding, X., Tang, N., & He, J. (2019). The threshold effect of environmental regulation, FDI agglomeration, and water utilization efficiency under 'double control actions'—An empirical test based on Yangtze river economic belt. *Water*, *11*(3), 452. https://doi.org/10.3390/w11030452

Dogan, E., Inglesi-Lotz, R., & Altinoz, B. (2021). Examining the determinants of renewable energy deployment: Does the choice of indicator matter? *International Journal of Energy Research*, *45*(6), 8780–8793. https://doi.org/10.1002/er.6413

Fotis, P., & Polemis, M. (2018). Sustainable development, environmental policy and renewable energy use: A dynamic panel data approach. *Sustainable Development*, *26*(6), 726–740. https://doi.org/10.1002/sd.1742

Gan, L., Eskeland, G. S., & Kolshus, H. H. (2007). Green electricity market development: Lessons from Europe and the US. *Energy Policy*, *35*(1), 144–155. https://doi.org/10.1016/j.enpol.2005.10.008

IEA (2010). *Energy Technology Perspectives: Scenarios and Strategies to 2050*. International Energy Agency, Paris, France.

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. *Energy Economics*, *53*, 58–63. https://doi.org/10.1016/j.eneco.2015.01.003
Intergovernmental Panel on Climate Change. (2018). Global warming of 1.5° C: an IPCC special report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Intergovernmental Panel on Climate Change.
Jenner, S., Groba, F., & Indvik, J. (2013). Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries. *Energy Policy*, *52*, 385–401. https://doi.org/10.1016/j.enpol.2012.09.046
Johnstone, N., Haščič, I., Poirier, J., Hemar, M., & Michel, C. (2012). Environmental policy stringency and technological innovation: Evidence from survey data and patent counts. *Applied Economics*, *44*(17), 2157–2170. https://doi.org/10.1080/00036846.2011.560110
Khan, M. K., Teng, J. Z., & Khan, M. I. (2019). Effect of energy consumption and economic growth on carbon dioxide emissions in Pakistan with dynamic ARDL simulations approach. *Environmental Science and Pollution Research*, *26*(23), 23480–23490.
Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N. N., Baldé, A. B., Bertollini, R., Bose-O'Reilly, S., Boufford, J. I., Breysse, P. N., Chiles, T., Mahidol, C., Coll-Seck, A. M., Cropper, M. L., Fobil, J., Fuster, V., Greenstone, M., Haines, A., … Zhong, M. (2018). The Lancet Commission on pollution and health. *Lancet (London, England)*, *391*(10119), 462–512.
Lei, W., Xie, Y., Hafeez, M., & Ullah, S. (2021). Assessing the dynamic linkage between energy efficiency, renewable energy consumption, and CO_2 emissions in China. *Environmental Science and Pollution Research*, 1–13. https://doi.org/10.1007/s11356-021-17145-7
Mardani, A., Streimikiene, D., Cavallaro, F., Loganathan, N., & Khoshnoudi, M. (2019). Carbon dioxide (CO2) emissions and economic growth: A systematic review of two decades of research from 1995 to 2017. *Science of the Total Environment*, *649*, 31–49.
Mardones, C., & Baeza, N. (2018). Economic and environmental effects of a CO_2 tax in Latin American countries. *Energy Policy*, *114*, 262–273. https://doi.org/10.1016/j.enpol.2017.12.001
Marques, A. C., & Fuinhas, J. A. (2012). Is renewable energy effective in promoting growth? *Energy Policy*, *46*, 434–442. https://doi.org/10.1016/j.enpol.2012.04.006
Menz, F. C., & Vachon, S. (2006). The effectiveness of different policy regimes for promoting wind power: Experiences from the states. *Energy Policy*, *34*(14), 1786–1796. https://doi.org/10.1016/j.enpol.2004.12.018
Omri, A., & Nguyen, D. K. (2014). On the determinants of renewable energy consumption: International evidence. *Energy*, *72*, 554–560. https://doi.org/10.1016/j.energy.2014.05.081
Ouyang, X., Fang, X., Cao, Y., & Sun, C. (2020). Factors behind CO_2 emission reduction in Chinese heavy industries: Do environmental regulations matter? *Energy Policy*, *145*, 111765. https://doi.org/10.1016/j.enpol.2020.111765
Pang, R., Zheng, D., Shi, M., & Zhang, X. (2019). Pollute first, control later? Exploring the economic threshold of effective environmental regulation in China's context. *Journal of Environmental Management*, *248*, 109275.
Pinto, R. G. D., Szklo, A. S., & Rathmann, R. (2018). CO_2 emissions mitigation strategy in the Brazilian iron and steel sector – From structural to intensity effects. *Energy Policy*, *114*, 380–393. https://doi.org/10.1016/j.enpol.2017.11.040
Rapanos, V. T., & Polemis, M. L. (2005). Energy demand and environmental taxes: The case of Greece. *Energy Policy*, *33*(14), 1781–1788. https://doi.org/10.1016/j.enpol.2004.02.013
Sadorsky, P. (2009). Renewable energy consumption and income in emerging economies. *Energy Policy*, *37*(10), 4021–4028. https://doi.org/10.1016/j.enpol.2009.05.003
Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy*, *38*(5), 2528–2535.
Salim, R. A., & Rafiq, S. (2012). Why do some emerging economies proactively accelerate the adoption of renewable energy?. *Energy Economics*, *34*(4), 1051–1057.

Sinn, H. W. (2008). Public policies against global warming: A supply side approach. *International Tax and Public Finance*, *15*(4), 360–394. https://doi.org/10.1007/s10797-008-9082-z

Sohail, M. T., Xiuyuan, Y., Usman, A., Majeed, M. T., & Ullah, S. (2021). Renewable energy and non-renewable energy consumption: Assessing the asymmetric role of monetary policy uncertainty in energy consumption. *Environmental Science and Pollution Research*, 1–10.

Taylor, C., Pollard, S., Rocks, S., & Angus, A. (2012). Selecting policy instruments for better environmental regulation: A critique and future research agenda. *Environmental Policy and Governance*, *22*(4), 268–292. https://doi.org/10.1002/eet.1584

Ullah, S., Ahmad, W., Majeed, M. T., & Sohail, S. (2021). Asymmetric effects of premature deagriculturalization on economic growth and CO_2 emissions: Fresh evidence from Pakistan. *Environmental Science and Pollution Research International*, *28*(47), 66772–66786.

Ullah, S., & Ozturk, I. (2020). Examining the asymmetric effects of stock markets and exchange rate volatility on Pakistan's environmental pollution. *Environmental Science and Pollution Research International*, *27*(25), 31211–31220.

Usman, A., Ozturk, I., Ullah, S., & Hassan, A. (2021). Does ICT have symmetric or asymmetric effects on CO_2 emissions? Evidence from selected Asian economies. *Technology in Society*, *67*, 101692. https://doi.org/10.1016/j.techsoc.2021.101692

Wang, K., Yan, M., Wang, Y., & Chang, C. P. (2020). The impact of environmental policy stringency on air quality. *Atmospheric Environment*, *231*, 117522. https://doi.org/10.1016/j.atmosenv.2020.117522

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and Statistics*, *69*(6), 709–748. https://doi.org/10.1111/j.1468-0084.2007.00477.x

Wolde-Rufael, Y., & Weldemeskel, E. M. (2020). Environmental policy stringency, renewable energy consumption and CO_2 emissions: Panel cointegration analysis for BRIICTS countries. *International Journal of Green Energy*, *17*(10), 568–582. https://doi.org/10.1080/15435075.2020.1779073

World Bank. (2016). *World development indicators 2016*. World Bank Publications.

Yang, H. C. (2021). Impact of environmental stringency on energy efficiency. *Energy Research Letters*, *2*(3), 25727. https://doi.org/10.46557/001c.25727

Yin, H., & Powers, N. (2010). Do state renewable portfolio standards promote in-state renewable generation?. *Energy Policy*, *38*(2), 1140–1149. https://doi.org/10.1016/j.enpol.2009.10.067

Zhang, Y., Sun, J., Yang, Z., & Wang, Y. (2020). Critical success factors of green innovation: Technology, organization and environment readiness. *Journal of Cleaner Production*, *264*, 121701. https://doi.org/10.1016/j.jclepro.2020.121701

Zhao, W., Hafeez, M., Maqbool, A., Ullah, S., & Sohail, S. (2021). Analysis of income inequality and environmental pollution in BRICS using fresh asymmetric approach. *Environmental Science and Pollution Research*, 1–11.

Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, *58*, 237–248. https://doi.org/10.1016/j.econmod.2016.05.003