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Does institutional quality matter for renewable energy promotion in OECD economies?

Shuddhasattwa Rafiq[1] | **Sudharshan Reddy Paramati**[2] | **Md. Samsul Alam**[3] | **Khalid Hafeez**[4] | **Muhammad Shafiullah**[5]

[1]Deakin Business School, Deakin University, Melbourne, Victoria, Australia

[2]School of Business, University of Dundee, Dundee, UK

[3]Derby Business School, University of Derby, Derby, UK

[4]Balochistan University of Information Technology, Engineering & Management Sciences (BUITEMS), Quetta, Pakistan

[5]Department of Economics and Social Sciences, Brac University, Dhaka, Bangladesh

Correspondence

Md. Samsul Alam, Derby Business School, University of Derby, Derby DE22 1GB, UK.

Email: m.alam@derby.ac.uk

Abstract

This study examines the effect of institutional quality on renewable energy promotion in OECD economies. The study employs annual data from 1980 to 2014 on 18 OECD economies. The robust panel unit root tests show that all the considered variables have a similar order of integration, indicating that they are nonstationary at their levels but stationary at the first-order differences. The panel cointegration test with structural breaks and cross-section dependence confirms a long-run equilibrium association between institutional quality, renewable energy consumption and control variables. The analysis of long-run estimations displays that better institutional quality makes a unique and substantial contribution to promoting renewable energy consumption. Overall, the study findings offer important policy implications highlighting the importance of institutional quality for the growth of renewable energy and a sustainable world.

KEYWORDS

carbon emissions, FDI inflows, institutional quality, OECD economies, renewable energy, sustainable world

1 | INTRODUCTION

The rise of global temperature, the negative consequences of climate change on the environment and the oil price volatility have put immense pressure on policymakers to consider the proportion of renewable energy in the overall energy mix. In response, policymakers have taken various measures, including tax credits and green certificates for renewable energy use, tax exemption for the system of renewable energy installation and subsidies for future renewable energy projects. These all have led to an incremental increase in the proportion of renewable energy in the world's total energy production and consumption. According to the International Energy Agency (IEA, 2021), in 1973, the shares of non-renewable (coal, oil and natural gas) and renewable (nuclear, hydropower, biofuels, etc.) energies to the total primary energy supply were 86.7% and 13.3%, respectively. However, in 2019, the shares for non-renewable and renewable energies increased to 80.9% and 19.1%, respectively (IEA, 2021). Among the predominant renewable energy sources, the portion of nuclear and hydropower increased by 4.1% (from 0.9% to 5%) and 0.7% (from 1.8% to 2.5%), respectively, while the share of biofuels and waste decreased by 0.8% (from 10.2% to 9.4%) during 1975 to 2019 (IEA, 2021).

The importance of renewable energy in today's economy has focused the attention of many researchers to identify the potential and impact of relevant economic factors that lead to increased renewable energy consumption. For instance, Sadorsky (2009a) and Gan and Smith (2011) suggest that the growth in gross domestic product (GDP) per capita and carbon dioxide (CO_2) emissions promoted renewable energy use in the Organization for Economic Co-operation and Development (OECD) nations for the period of 1994 to 2003. Similarly, Omri and Nguyen (2014) claim that CO_2 emissions and international trade are the main factors for renewable energy consumption. Reboredo (2015) empirically reports that the rise in oil prices positively affects the use of renewable energy, whereas Sadorsky (2009a) and Rafiq et al. (2014) find a negative connection between energy prices and renewable energy. Paramati et al. (2016) identify that foreign direct investment (FDI) positively influences clean energy use in 20 emerging countries during 1991–2012. These authors also argue that strong stock markets positively contribute to clean energy use through green energy financing projects. Employing Chinese data from 1980 to 2011, Lin et al. (2016) highlight that financial development encourages renewable electricity consumption. In the same vein, Paramati et al. (2017) suggest that political cooperation plays a vital role in enhancing renewable energy use. Kutan et al. (2018) also support Paramati et al. (2016) work reporting that the growth in FDI inflows and development of stock markets promote renewable energy use in most of the emerging market nations. Recently, Shafiullah, Miah et al. (2021) posited that economic policy uncertainty negatively affects renewable energy consumption. At the firm level, board gender diversity (Atif et al., 2021) and cash holding (Alam et al., 2022) are found to be important determinants of renewable energy consumption.

While there are a number of empirical research examples examining the factors contributing to renewable energy consumption, an extant literature review reveals a lack of research that investigates the influence of institutional quality in promoting renewable energy consumption in the OECD countries. This can happen in various ways. First, the production and consumption of renewable are highly policy-relevant since the technology and know-how of renewable energy are expensive (Aguirre & Ibikunlee, 2014). Public support schemes such as tax credits, subsidies, quota allocation, green certificates and other financial and non-financial incentives are extremely important in promoting renewable energy production and consumption (Gennaioli & Tavoni, 2016). Developing strong institutions is included in the United Nations Sustainable Development Goal (UNSDG 16). This is defined as essential to 'substantially reduce corruption and bribery in all their forms, develop effective, accountable and transparent institutions at all levels and ensure responsive, inclusive, participatory and representative decision-making at all levels'.

Institutional quality (IQ) is a summary index using government size, legal rights and property rights. In this connection, strong institutions and good governance can first make politicians and governments accountable for adopting environmental policies and legislation that encourage renewable energy production and consumption (Carley, 2009). Second, stronger institutions enforce and implement stringent environmental policies that provide guidelines and standards and encourage businesses to comply with national and international environmental rules and regulations. Moreover, strong institutions help to combat corruption in the energy sector by strengthening the legal and judicial system and raising the voice of civil society in demanding better environmental management (World Bank, 2018). As a result, businesses follow sustainable practices and employ firms' resources and capabilities in environmentally friendly products, processes and technologies that encourage renewable energy use (Banerjee et al., 2019). Conversely, in the presence of weaker institutions, businesses may become prone to corrupt practices and bribes, which allow polluting firms to get laxer environmental regulations and poor enforcement and may receive favourable signals to pollute environment (Candau & Dienesch, 2017). Third, strong (quality) institutions encourage renewable energy consumption indirectly by ensuring economic growth. Strong institutions have been found to increase economic growth and development (see Dollar & Kraay, 2003; Fatas & Mihov, 2013), which may positively influence renewable energy consumption (Gan & Smith, 2011; Sadorsky, 2009a).

Given this backdrop, the present study is to empirically explore the influence of institutional quality on renewable energy consumption in a sample of 18 OECD economies. Further, the study measures the impact of renewable energy consumption on CO_2 emissions using an environmental theoretical model, that is, STIRPAT. To accomplish these objectives, this study makes use of the longest available annual dataset from 1980 to 2014 and employs relevant and latest econometric techniques to analyse panel data.

The study offers three main contributions. Firstly, as noted earlier, this empirical study analyses the nexus between institutional quality and renewable energy consumption. Hence, this research contributes to a growing strand of empirical literature (e.g., Alam et al., 2021; Paramati et al., 2021; Shafiullah, Miah, et al., 2021) identifying the determinants of renewable energy consumption. Secondly, the empirical analysis used in this study follows a widely used environmental theoretical model to choose variables in the empirical setting. A large number of studies, such as York et al. (2003), Li et al. (2011), and Wang et al. (2013), use the STIRPAT model to assess the effects of socio-economic factors on environment quality. This study extends this literature stream by investigating institutional quality's impact on renewable energy consumption.

Thirdly, this research uses a battery of the latest panel econometric methodologies, accounting for cross-sectional dependence, dynamic relationships and structural breaks in the estimation. Therefore, the estimated results applying these techniques provide more robust, stable and reliable results than previous studies. These are particularly important when data availability remains the key limiting factor in the empirical exercises. Employing long-run estimates, the empirical results of this research show that institutional quality plays a significant role in promoting renewable energy. Further, the findings confirm that renewable energy consumption, FDI inflows and stock markets contribute to environmental sustainability by reducing CO_2 emissions. Considering these results, the findings suggest that institutional quality has a significant role in promoting renewable energy use, while renewable energy consumption, FDI and stock markets have mitigating consequences on CO_2 emissions in the OECD countries.

These findings offer important policy implications for attaining UN sustainable development goals. Specifically, these selected countries should improve their regulatory system and may force their listed companies in the stock exchange to follow environmental, social and governance (ESG) practices, which will further assist those countries in mitigating the growth of carbon emissions by moving towards more environmentally sustainable practices. Similarly, these countries can also improve their institutional setup to promote renewable energy projects using significant FDI inflows, bring not only foreign capital but also advanced technologies, which can help these economies improve their energy mix through the generation and consumption of renewable energy sources. This will then eventually improve environmental sustainability by reducing carbon emissions.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature, identifies the research gap and discusses the context of the study. Section 3 highlights the nature of data, their measurement and the empirical methodology, while Section 4 focuses on the empirical findings and their discussion. Finally, Section 5 offers policy implications, while Section 6 concludes the paper with future research directions.

2 | LITERATURE REVIEW

Considering the significance of renewable energy for sustainable development, a wide range of existing literature has been examined to investigate this issue. This section presents a review of the current and relevant literature in two sub-sections. The first section discusses the socio-economic factors, while the second section highlights the political factors that stimulate renewable energy consumption.

2.1 | Socio-economic factors and renewable energy consumption

The literature identifies several socio-economic factors, including GDP, carbon emissions and energy prices, which are pivotal in influencing the demand for renewable energy. A country's income level, measured by GDP per capita, is one of the significant factors in deploying renewable energy. Generally, developed countries have more resources and capabilities at their disposal to invest in renewable energy technologies, which eventually foster renewable energy production and consumption. A group of studies, such as Sadorsky (2009a) for G-7 countries during the period 1980–2005; Sadorsky (2009b) for 18 emerging countries from 1994 to 2003; Salim and Rafiq (2012) for six developing nations between 1980 and 2006; and Kutan et al. (2018) for four important emerging nations (Brazil, China, India and South Africa) during the 1990–2012 period, find that the rise in income per capita intensifies renewable energy consumption significantly. Apergis and Payne (2010a) for major OECD nations, Apergis and Payne (2010b) for Eurasia and Ohler and Fetters (2014) for 20 OECD nations provide empirical evidence on the support for a bidirectional relationship between them, indicating that both income and renewable energy cause each other simultaneously. However, Menegaki (2011) reports no causal connection between income and renewable energy use for 27 European nations between 1997 and 2007.

Considering the detrimental impact of greenhouse gases on climate change, higher carbon emissions promote the demand for sustainable development and foster the demand for renewable energy consumption. The literature also highlights that rising carbon emissions increase renewable energy production and supply. Therefore, many studies employ carbon emission in their econometric model to estimate the effect of it on renewable energy deployment. Among these, Sadorsky (2009a) for G-7 countries, Omri and Nguyen (2014) for 64 countries and Rafiq et al. (2014) for China and India suggest that the increase in carbon emissions has a significant positive impact on fostering renewable energy. However, Marques et al. (2010) have reported a substantial negative link between renewable energy use and CO_2 emissions. However, these authors acknowledge that their findings are surprising, and they failed to provide any arguments to support their results.

The price of energy is also found to be a significant factor in determining renewable energy consumption. Traditionally, fossil fuel price is relatively cheaper than renewable energy since it does not consider the environmental cost. However, due to the rapid development of technology for clean energy production, the cost of clean energy has started falling and become cheaper sometimes. In this connection, Bird et al. (2005) point out that the growing price competitiveness of wind-generated electricity motivates the US government and institutions to instal new wind energy. Van Rujiven and Van Vuuren (2009) also claim that renewable energy production is becoming popular for its lower price. Reboredo (2015) empirically supports that the rise in oil prices significantly influences renewable energy use. Nevertheless, Sadorsky (2009a) and Rafiq et al. (2014) suggest that increasing oil prices negatively affects renewable energy consumption.

Recent studies measure the influence of other economic variables, including FDI, urbanization, trade openness, stock market and financial development, on the deployment of renewable energy. Lee (2013) explores the link between FDI and renewable energy use in G20 nations. Employing panel data from 1971 to 2009, the study finds that FDI has no significant relationship with clean energy use. Lin et al. (2016) also support the findings of Lee (2013). Employing the annual data from 1980 to 2011 in China, the study reveals that financial development has an important positive, but FDI and trade openness have no considerable effect on renewable electricity use. Paramati et al. (2016) investigate the influence of stock market development and FDI on clean energy use in 20 emerging countries. Using data from 1991 to 2012, the study documents that both stock market development and FDI promote clean energy use. The impact of the stock market is also found to stimulate demand for renewable energy in G-20 countries from 1991 to 2012 Paramati et al. (2017). In the same line, Chen (2018) identifies the factors promoting renewable energy consumption using 30 Chinese provincial data from 1996 to 2013. The dynamic system generalized method of moments (GMM) test result indicates that, along with other variables, urbanization and foreign trade play a central part in encouraging the use of renewable energy in some provinces. da Silva et al. (2018) empirically support that the growth in population has a considerable negative influence on the supply of renewable energy in sub-Saharan Africa covering the period of 1990 to 2014. Recently, Alam et al. (2021) and Paramati et al. (2021) found that Research and Development (R&D) investment improves environmental sustainability by increasing renewable energy consumption share in OECD and European member countries.

2.2 | Political factors and renewable energy consumption

Many studies highlight the importance of political factors, such as government policies, membership in regional and global institutions and agreements, energy securities, and bilateral and multinational political aid and cooperation. For example, Jenner et al. (2013), Smith and Urpelainen (2014), Stadelmann and Castro (2014) and Kilinc-Ata (2016) point out that public policies, such as feed-in tariffs (FIT) (introduced in 2101 in the UK to incentivize the businesses and homeowners to generate on-site small-scale renewable energy), government subsidies, R&D, quota allocations and green certificates, are the significant driving forces for the growth of renewable energy. Yin and Powers (2010) empirically show that quota has a noteworthy positive effect on producing renewable energy. In the same vein, Jenner et al. (2013) find robust evidence that the FIT policy drives solar energy development in European countries. Similarly, Smith and Urpelainen (2014) examine the causal impact of FIT on renewable energy production in 26 industrialized nations during the 1979–2005 timeline. The econometric analysis shows that if the FIT increases by one US cent, then the per cent of renewable electricity to the total energy mix increases by 0.11% points. Sardianou and Genoudi (2013) reveal that tax reduction is one of the most effective and useful policy instruments to foster renewable energy deployment. Kilinc-Ata (2016) recently evaluated the major policy instruments in the 27 EU nations and 50 US states. Covering the period of 1990 to 2008, the study provides empirical evidence that FIT, tax incentives and public sector tenders are the most effective public policies to promote renewable energy production.

Regional or global institutions such as the European Union, African Union, G-7 and the United Nations set goals to combat climate change and reduce carbon emissions through promoting renewable energy deployment (da Silva et al., 2018). Moreover, various environmental treaties and agreements also set targets and undertake many agendas to battle global warming. For example, 195 nations accepted and implemented the global climate agreement in Paris (COP21) in December 2015. The agreement legally compels the whole world to commence several climate change actions to maintain the global temperature of $<2°C$. Thus, the membership of these institutions and agreements is encouraged to raise their renewable energies in total energy mix. These arguments are also reinforced by empirical literature. For instance, Popp et al. (2011) and Aguirre and Ibikunle (2014) document that nations' participation in international institutions positively correlated with renewable energy. Schaffer and Bernauer (2014) also identify that the EU membership contributes significantly to rising renewable energy production in 26 industrialized countries.

In addition, several studies suggest that the dependence on energy security is also considered an important policy for fostering renewable energy. Gan et al. (2007) argue that countries with high dependency on imported energy are more likely to deploy renewable energy. Similarly, Marques et al. (2010) report that high energy import dependency is positively linked to the growth of renewable energy in 24 European nations between 1990 and 2006. However, Aguirre and Ibikunle (2014) provide different empirical evidence. The finding indicates that nations are likely to diminish renewable promises when they face pressure of safeguarding energy security. Among other political factors, international energy aid and cooperation are vital for increasing renewable energy supply. Ince et al. (2016) suggest that the influence of international organizations facilitates the advancement of renewable energy in the Caribbean countries. In addition, considering sub-Saharan Africa as a case study, da Silva et al. (2018) conclude that energy aid significantly led to renewable energy growth between 1990 and 2014. Paramati et al. (2017) provide empirical evidence in favour of political globalization, which greatly enhances clean energy consumption and mitigates CO_2 emissions. Finally, Shafiullah, Miah et al. (2021) show a negative long-run relationship between policy uncertainty and renewable energy consumption.

2.3 | Research gaps and context of the study

This literature review highlights that numerous studies have examined the determinants of renewable energy use in advanced and emerging economies. These studies emphasize a wide range of social, economic and political factors. However, little is known regarding the role of (strong) institutional quality in promoting renewable energy consumption. This study fulfils this research gap to address the impact of strong institutions on the consumption and promotion of renewable energy sources in OECD countries.

The choice of OECD countries as a sample is motivated by two reasons. First, in general, OECD countries have relatively accountable, effective and inclusive institutions that ensure fair and efficient natural resource use and corruption reduction, provide citizens access to information and empower them to hold the government accountable for their actions. These strong institutions play a vital role in sustainable development by enforcing stringent environmental laws and regulations (OECD, 2015). Second, most OECD nations signed the Paris Agreement to decrease their overall carbon emissions and maintain the rise of world temperature up to 2°C (UNFCC, 2018). Thus, these countries exert their best efforts to raise the supply of renewable energy in their energy mix to mitigate the detrimental consequences of climate change. These efforts include numerous government financial and technical incentives such as subsidies for renewable technologies, green certificates, tax credits and tariff exemptions. Consequently, in OECD countries (in 2016), the proportion of renewables in the total primary energy supply exceeds 0.5 million tons of oil equivalent (toe), which is almost 10% of the OECD's total primary energy supply (OECD, 2018). Therefore, examining the connection between institutional quality and renewable energy use from OECD countries is interesting and highly relevant for policy implications.

3 | NATURE OF DATA AND EMPIRICAL METHODOLOGY

3.1 | Data description

This study uses annual data from 1980 to 2014 on 18 OECD economies. The OECD economies included in the sample are Austria, Australia, Canada, Denmark, France, Finland, Germany, Israel, Japan, South Korea, Mexico, Norway, the Netherlands, Spain, Switzerland, Sweden, the UK and the US. The choice of the sample countries and period was based on data availability. The measurements of selected variables are as follows: total renewable energy uses (REC) in kilotons of oil equivalent (KTOE); sources of renewable energy cover solar, hydro, geothermal, tide, wind and wave; the total CO_2 emissions (CO_2) are in millions of metric tons; total population (POP); per capita GDP (PI) in constant 2010 US\$; the institutional quality (IQ)[1] is a summary index using government size, legal rights and property rights, trade freedom, sound money and regulation; the foreign direct investment (FDI); net inflows as a percentage of GDP (FDI)[2]; and finally total stock market capitalization as a percentage of GDP (SMC). The required data on REC were collected from the OECD online database; CO_2 emission data were sourced from the U.S. Energy Information Administration (EIA) online database. Finally, the data on POP, PI, FDI and SMC were collected from the World Bank sources, whereas data on IQ were obtained from the Fraser Institute's online data bank. Since the selected (model) variables used in this research are captured in various units, they are all transformed into natural logarithms prior to the commencement of the empirical investigations.

3.2 | Theoretical model and empirical specification

Several studies (e.g., Kutan et al., 2018; Paramati et al., 2016, 2017) argue that per capita income, FDI inflows and stock markets are critical in promoting renewable energy generation and consumption. However, the previous literature has paid a limited attention to the institutional quality in promoting renewable energy consumption. Given that, this study explores the influence of institutional quality on renewable energy promotion by taking relevant variables like per capita income, FDI inflows and stock market development as controls. The study also explores the effect of the use of renewable energy on CO_2 emissions using a theoretical environmental model, that is, the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT), which is an extension of the IPAT model and proposed by Dietz and Rosa (1994, 1997) given below:

$$\mathrm{REC}_{i,t} = \beta_0 + \beta_1 \mathrm{PI}_{i,t} + \beta_2 \mathrm{IQ}_{i,t} + \beta_3 \mathrm{FDI}_{i,t} + \beta_4 \mathrm{SMC}_{i,t} + \mu_{i,t} \tag{1}$$

where REC, PI, IQ, FDI and SMC represent renewable energy consumption, GDP per capita, institutional quality, foreign direct investment and stock market capitalization, respectively, while i, t and μ ε indicate cross-section (country), time period and error term, respectively. The first equation aims to find the factors that influence renewable energy use in the selected OECD economies. This equation estimates the contemporaneous (i.e., at time t) impact of the right-hand side variables on renewable energy consumption. This model specification is also aligned with the extant literature, including Shafiullah, Miah et al. (2021) and Miah et al. (2023), who examine the contemporaneous (at time t) impact of economic policy uncertainty and financial stress, as well as other controls, on U.S. renewable energy consumption, respectively.

As mentioned above, the extended version of the environmental theoretical model, that is, the STIRPAT model, is used to analyse the influence of renewable energy uses on carbon emissions (CO_2) by considering other determinants in the model, such as population (POP), per capita income, renewable energy consumption, FDI inflows and stock market development indicators:

$$\mathrm{CO}_{2,i,t} = \beta_0 + \beta_1 \mathrm{POP}_{i,t} + \beta_2 \mathrm{PI}_{i,t} + \beta_3 \mathrm{REC}_{i,t} + \beta_4 \mathrm{FDI}_{i,t} + \beta_5 \mathrm{SMC}_{i,t} + \mu_{i,t} \tag{2}$$

This model is in line with the extant studies, such as Li et al. (2011), Wang et al. (2013) and Shafiullah, Papavassiliou et al. (2021), which investigate the determinants of carbon emissions in the context of different countries. Prior to estimating the above models, a battery of tests is undertaken to analyse individual series to identify appropriate econometric strategies to adopt. These investigations started with the panel data unit root tests, namely Dickey and Fuller (1979) and Philips and Perron (1988) tests (based on the Maddala and Wu (1999) version), Breitung (2000), Levin et al. (2002) and Im et al. (2003) tests to assess unit root properties of the relevant variables. The findings show REC, CO_2, POP, PI, IQ, FDI and SMC were reasonably constant, suggesting their non-stationary characteristics.[3] In addition, a nonlinear unit root test developed by Emirmahmutoglu and Omay (2014) is implemented. Moreover, the Carrion-i-Silvestre et al. (2005) panel unit root test is conducted, which allows for as many as five structural breaks. As the last step of individual series diagnostics, cross-section dependence (CSD) through Friedman (1937), Frees (1995) and Pesaran's (2004) CSD tests is investigated. To identify possible cointegrating relationships among the variables, in addition to standard tests of Pedroni (2001) and Westerlund (2007), the Banerjee and Carrion-i-Silvestre (2013) cointegration test is conducted. The benefit of these cointegration tests is that they account for both CSD and structural breaks while examining the null hypothesis of no cointegration. If detected, cointegrating relationships imply long-run equilibria between the variables in model specifications (1) and (2). Long-run equilibria or cointegration imply that relationships between the dependent and independent variables exist in the long run, in addition to the short run—that is, at time t as well as prior periods (t–1, t–2, etc.). Cointegration also implies that any short-run shock to the system is corrected in the long run, thus lending the term 'error-correction model' (see, e.g., Engle & Granger, 1987; Gregory & Hansen, 1996; Shahbaz et al., 2017; Shafiullah, Miah et al., 2021; Shafiullah, Papavassiliou et al., 2021).

In this study, seven panel data estimation techniques are implemented to allow for possible issues like cross-sectional dependence, endogeneity, omitted variable, bias, nonlinearity and dynamic relationships. This study's multivariate panel data estimators cover three first-generation models and three second-generation estimators permitting cross-sectional dependence, heterogeneity and dynamic effects. The first-generation models include fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS) and generalized method of moments (GMM) techniques. The hypothesis of linearity may not always hold. Thus, the empirical analysis also undertakes a recently developed nonlinear second-generation test (allowing for cross-sectional dependence and heterogeneity) offered by Kapetanios et al. (2014), which is widely known as KMS (2014). One novel feature of the test is that it endogenously creates both 'strong' and 'weak' cross-sectional dependence. Furthermore, models (1) and (2) are modified by incorporating lagged independent variables and estimated using the KMS 2014 method. Given the above points, this study's estimation methods are expected to provide more reliable results by accounting for a number of issues in the panel regression estimation—often sidelined by the extant literature.

4 | EMPIRICAL FINDINGS AND DISCUSSION

To begin the empirical investigation, the first step is to investigate whether given data series are cross-sectionally dependent, as it will help to choose the right econometric methodology for achieving the study objectives. To this end, three cross-sectional dependence tests are applied: Pesaran (2004), Frees (1995) and Friedman (1937). The results of these tests from models 1 to 2 are displayed in Table 1. The results from fixed and random effect estimations confirm that the two selected models have considerable cross-sectional dependence. This aligns with prior literature—such as Paramati et al. (2021) and Shafiullah, Papavassiliou et al. (2021)—where macroeconomic panel (including cross-country) datasets and models exhibit cross-section dependence. The models were also significant at the 5% significant levels. Therefore, the economic models chosen for further analysis must consider cross-sectional dependence while estimating the parameters. Failing to do this, the findings derived from other estimators will be spurious and may arrive with misleading interpretations.

Based on the evidence of cross-sectional dependence across the models, panel unit root tests were chosen, considering both cross-sectional dependence and structural breaks in the given data series. Before proceeding with more rigorous analyses, it is important to understand the distributional properties of each of the considered variables. Specifically, it is important to understand the order of integration of the selected variables to assist in selecting the appropriate econometric technique for the empirical investigation. Table 2 displays the results derived from the panel unit root tests. The results suggest that the calculated test values are significantly higher than the critical values for all of the considered variables. Therefore, this confirms that the alternative hypothesis of non-stationarity is accepted at the 5% significance levels for selected variables. These findings establish that all selected variables have identical order of integration, that is, $I(1)$. The table also presents structural breaks for each of the model variables. However, the structural break dates are inconsistent for all selected variables. Further, the nonlinear Emirmahmutoglu and Omay (2014) panel unit root test is applied, and the results are given in Table 3. The findings indicate that all of the considered variables have a similar order of integration, meaning they are nonstationary at their levels but stationary at the first-order differences. The literature examining cross-country 'long panels' generally observes unit root, and sometimes structural breaks, in their model variables—see, for example, Paramati et al. (2017), Shahbaz et al. (2017), Paramati et al. (2018), and Paramati et al. (2021), inter alia. Hence, both of these unit root tests provide consistent results on all of the selected variables. From these panel unit root tests, the long-run equilibrium association is examined among the variables of Equations (1) and (2) in the following paragraphs.

As mentioned previously, the considered models suffer from cross-sectional dependence. Hence, a panel cointegration test is applied that accounts for cross-sectional dependence and structural breaks to estimate

TABLE 1 Cross-sectional dependence tests.

	Pesaran		Frees		Freidman	
Tests	**CD test**	***p*-value**	**CD(Q) test**	***p*-value**	**CD test**	***p*-value**
Model I						
FE estimation	13.317***	0.0000	4.533***	0.0000	151.043***	0.0000
RE estimation	13.552***	0.0000	4.428***	0.0000	152.636***	0.0000
Model II						
FE estimation	4.037***	0.0001	5.419***	0.0000	56.002***	0.0000
RE estimation	3.973***	0.0001	5.453***	0.0000	55.757***	0.0000

Note: FE and RE denote fixed and random effect estimations. (***), (**) and (*) indicate that the test statistics is significant at 1%, 5% and 10% levels, respectively.

TABLE 2 Panel unit root test with structural breaks.

Variables	Carrion-i-Silvestre et al. (LM(λ)) Test	Bootstrap critical value (5%)	Break location (T_b)
REC			
$\Psi_{\bar{t}}$	12.921**	9.472	1999, 2005, 2008, 2013, 2014
$\Psi_{\overline{LM}}$	12.653**	9.472	
CO_2			
$\Psi_{\bar{t}}$	24.518**	8.235	1985, 1986, 1988, 2005, 2011
$\Psi_{\overline{LM}}$	23.587**	8.235	
POP			
$\Psi_{\bar{t}}$	13.284**	9.308	1990, 1993, 2005, 2009, 2014
$\Psi_{\overline{LM}}$	12.378**	9.308	
PI			
$\Psi_{\bar{t}}$	17.819**	8.203	1980, 1983, 1996, 2005, 2012
$\Psi_{\overline{LM}}$	16.227**	8.203	
IQ			
$\Psi_{\bar{t}}$	12.250**	9.371	1980, 1994, 1997, 2003, 2005
$\Psi_{\overline{LM}}$	11.653**	9.371	
FDI			
$\Psi_{\bar{t}}$	11.681**	8.660	1980, 1996, 2007, 2011, 2013
$\Psi_{\overline{LM}}$	11.190**	8.660	
SMC			
$\Psi_{\bar{t}}$	13.063**	8.660	1991, 1994, 2001, 2013
$\Psi_{\overline{LM}}$	12.247**	8.660	

Note: The number of unknown structural break is set to be 5. The null of LM (λ) test implies stationarity. The Gauss procedure is undertaken based on the code provided by Ng and Perron (2001). The tests are computed using the Bartlett kernel, and all the bandwidth and lag lengths are chosen according to $4(T/100)^{2/9}$. The bootstrap critical value allows for cross-section dependence. Individual country break dates are also computed, to be furnished upon request. (***), (**) and (*) indicate that the test statistics is significant at 1%, 5% and 10% levels, respectively.

TABLE 3 Nonlinear unit root test of Emirmahmutoglu and Omay (2014).

Level variable	$\overline{F}_{AE}$	$\bar{t}_{UO}$	$\bar{t}_{IPS_B^c}$
REC	7.544*** (0.000)	−12.728* (0.050)	−8.409*** (0.000)
CO_2	17.324*** (0.000)	−6.327** (0.000)	−5.837*** (0.000)
POP	6.098***(000)	−3.251***(0.000)	−2.037***(0.000)
PI	11.315*** (0.025)	−5.449*** (0.000)	−6.118*** (0.000)
IQ	4.623*** (0.000)	−9.472*** (0.000)	−3.253** (0.021)
FDI	8.001*** (0.000)	−3.798*** (0.000)	−6.152*** (0.000)
SMC	4.581*** (0.000)	−5.819*** (0.000)	−5.624** (0.030)

Note: (***), (**) and (*) indicate that the test statistics is significant at 1%, 5% and 10% levels, respectively. The numbers in the parentheses indicate the bootstrap *p*-values. The UO and IPS tests performed here are second-generation tests. *B* in the IPS test statistics denotes sieve bootstrap approach.

the long-run equilibrium association among the selected variables of Equations (1) and (2). The results of the cointegration test are displayed in Table 4. The presented results strongly endorse that the selected models have a significant long-term cointegration relationship. From these results, it is confirmed that the considered variables in each of the models are strongly associated over the long run. The extant literature (such as Dietz &

TABLE 4 Panel cointegration test with structural breaks and cross-sectional dependence.

	Model I	Model II
% Individual rejections at the 5% level of sig.	61.11%	44.44%
Panel data test statistic $[t^{\tau}_{\hat{e}^*_i}(\lambda_i)]$	−5.64	−2.61
$\hat{r}$	12	8
$\hat{r}^P$	2	1
$\hat{r}_1^{\text{NP}}$	3	1

Note: Maximun numbers of factors allowed are $r_{\max} = 12$. BIC in Bai and Ng (2004) is employed to estimate the optimum number of common factors ($\hat{r}$). Model 5 of Banerjee and Carrion-i-Silvestre (2013) test is chosen: that is, stable trend with the presence of multiple structural breaks affects both the level and the cointegrating vector of the model. Hence, this test has further reported two break dates for each individual, which are not presented here; however, they could be furnished upon request.

TABLE 5 KMS (2014) threshold nonlinear model of cross-sectional dependence for REC and CO_2.

Elasticities	Model I	Model II
PI	1.2699*** (6.532)	0.4318*** (31.8668)
IQ	0.6543*** (8.268)	
REC		−0.009*** (−7.0569)
FDI	−0.0007 (−1.295)	−0.0007*** (−7.4751)
SMC	0.0001*** (2.539)	−0.0003*** (−15.5954)
POP		1.3899*** (23.7788)
R	0.027	0.182
ρ	−0.624*** (−4.271)	−0.713*** (−11.232)

Note: These are the PCCE-KMS estimators proposed by Pesaran (2006) where ft = { t, *t*}. *r* and ρ are the threshold and the spatial autoregressive parameters. (***), (**) and (*) indicate that the test statistics is significant at 1%, 5% and 10% levels, respectively.

Rosa, 1994, 1997; Kutan et al., 2018; Paramati et al., 2016, 2017) detects long-run equilibria between the variables similar to those model Equations (1) and (2). However, this study is the first to observe cointegration among these variables altogether. However, at this stage, the econometric analyses are unable to find out the nature of cause-and-effect association among these variables. Therefore, the following analyses aim to examine the nature of the effect between dependent and independent variables.

To examine the nature of the association between dependent and independent variables of Equations (1) and (2), a nonlinear regression model is employed that accounts for cross-sectional dependence in the analysis. The results are reported in Table 5. The important points from the findings are discussed below. First, the results suggest that a 1% growth in institutional quality significantly increases renewable energy uses by 0.65%. This finding is consistent with Carley (2009), the World Bank (2018), Rahman and Sultana (2022) and Wang et al. (2022), who argue that strong institutions and good governance play a crucial role in promoting renewable production and consumption through increasing accountability among politicians, strengthening the legal and judicial system to implement stringent environment policies and raising the voice of the civil society in demanding better environmental management including the promotion of renewable energy consumption. Second, the results show that stock market development has a noteworthy influence on renewable energy uses across the sample of OECD economies at the 1% significance levels. This finding can be argued that highly developed stock markets might have provided a platform for renewable energy firms to float their stocks on the stock exchanges. Moreover, due to the higher regulatory framework in place, these stock markets might have insisted all the listed firms reduce fossil fuel consumption by substituting with renewable energy. Therefore, the stock exchange authority may penalize the firms that fail to take necessary actions to reduce carbon emissions. In addition, these rationales enable to conclude that the stock markets help attract investments in renewable energy schemes and create demand for renewable energy. The extant literature also supports the positive impact of stock market development on renewable energy consumption. For example, Paramati et al. (2018) and Alam et al. (2021) report that developed stock markets are positively linked to minimizing environmental degradation.

Third, the results suggest that a 1% GDP per capita increases in renewable energy consumption by 1.27%. This finding can be supported by the fact that as individuals become wealthier, they start paying more attention to their actions that affect the environment. Therefore, a higher income level may positively contribute to renewable energy uses, particularly in developed economies such as the OECD. A few previous studies, such as Sadorsky (2009a, 2009b) and Kutan et al. (2018), also find a similar impact of income on renewable energy consumption.

Fourth, the findings on the determinants of CO_2 emissions indicate that higher FDI inflows, renewable energy use and stock market development play essential roles in reducing the level of CO_2 emissions in the OECD economies. Nevertheless, the growth in population and GDP per capita still has important influence on increasing CO_2 emissions. The findings also establish that stock market development helps reduce overall CO_2 emissions. This is in line with the practical expectation that as the stock market develops, they pay considerable attention to the listed firms and their effect on the environment. In this way, the stock markets insist the listed firms adopt

TABLE 6 Panel causality test based on pooled mean group (PMG) analyses for emissions.

	Sources of causation						
	Short run (χ^2)						Long run
Depnt. variable	Δ PI	Δ IQ	Δ REC	Δ FDI	Δ SMC	Δ POP	ECT
REC							
Model I	78.95*** (0.00)	53.85*** (0.00)		4.83** (0.02)	0.14 (0.71)		−0.133*** (0.00)
CO_2							
Model II	36.24*** (0.00)		2.94* (0.08)	1.45 (0.23)	18.32*** (0.00)	1.95 (0.16)	−0.110*** (2.72)

Note: χ^2 tests have been undertaken for short-run analyses. *p*-values are provided in the parentheses. ETC indicates estimated error correction terms. The Schwarz information criterion (SIC) has been used to determine the optimum lag length. (***), (**) and (*) indicate that the test statistic is significant at 10%, 5% and 1% levels, respectively. *p*-values are in the parentheses.

more energy-efficient and environmentally friendly technology and know-how in their manufacturing activities. Consequently, the stock markets may play an important role in reducing the growth of CO_2 emissions. These findings, albeit novel, are aligned with the earlier work by Alam et al. (2021), who suggested that the stock market has a negative impact on the growth of carbon emissions. Similarly, the additional results of the present study disclosed that the increase in per capita income and population put more pressure on CO_2 emissions, which are also consistent with the environmental theoretical model.

Then, the Granger causality test is conducted by employing a pooled mean group approach. Table 6 presents the causality test results in the short run and long run. The Equation (1) results indicate causality from GDP per capita, institutional quality and FDI inflows to renewable energy consumption. Further, the result of the error correction term is negative, which confirms that the selected variables in the model have a significant long-run relationship. Similarly, the causality test results of Equation (2) confirm unidirectional causality from per capita income, renewable energy and stock market development to CO_2 emissions. Again, the error correction term is negative and significant, establishing a long-run association among the variables. Overall, the causality test results show considerable association among the selected variables of the models both in the short run and long run. The combined findings of institutional quality Granger causing renewable energy use and renewable energy use Granger causing CO_2 emissions are novel and unique to this study. However, these findings are partly in line with the prior studies that test this question, often for other countries and samples (e.g., Mehmood, 2021; Rahman & Sultana, 2022; Wang et al., 2022; Uzar, 2020). The remaining findings from the panel Granger causality tests remain in line with the extant literature, such as Alam et al. (2021), Kutan et al. (2018), Paramati et al. (2016, 2017), Shahbaz et al. (2017), Shafiullah, Miah et al. (2021) and Shafiullah, Papavassiliou et al. (2021), among others.

To ensure the robustness of these findings, FMOLS, DOLS and GMM techniques are employed on Equations (1) and (2), and the corresponding result models are highlighted in Table 7. The findings from all these methods suggest that the growth in GDP per capita, institutional quality and FDI inflows has a considerable positive influence on renewable energy consumption in the OECD countries. Similarly, the findings of these methods (from Equation (2)) show that the growth in population and per capita income has a positive effect on increasing CO_2 emissions, while the increase in renewable energy use and development of the stock market have an adverse impact. Moreover, additional robustness checks are conducted by estimating the REC and CO_2 elasticities using lagged (or '*t*–1') transformations of the independent variables in Equations (1) and (2). The KMS (2014) nonlinear threshold regression method is used to re-estimate these modified model equations. Overall, the lagged independent variable model estimation findings in Table 8 remain virtually identical (both in sign and magnitude) and support the findings as described earlier.

Furthermore, the structural break test of Carrion-i-Silvestre et al. (2005) is conducted to examine how the nonlinear interactions of renewables and emissions with selected control variable alterations across different regimes are distinguished by various breakpoints. In this study, the year 2005 was taken as the break date for the regime (since all selected variables had a structural break around that time) to estimate the relevant structural regime-threshold model. This is in line with the approaches of Enders and Granger (1998) and Hansen (1999), who allow regimes to be defined by at least one threshold variable through:

TABLE 7 FMOLS, DOLS and GMM-based REC and CO_2 elasticities.

	Model I			Model II		
Elasticities	FMOLS	DOLS	GMM	FMOLS	DOLS	GMM
PI	1.194*** (4.67)	1.579*** (3.52)	1.261*** (8.71)	0.521*** (8.01)	0.154* (1.80)	0.442*** (12.07)
IQ	2.639*** (4.65)	2.015*** (2.89)	2.777*** (8.68)			
REC				−0.032* (−2.04)	−0.011 (−0.68)	−0.027*** (−2.97)
FDI	0.034*** (4.46)	0.041*** (2.79)	0.022*** (4.89)	−0.001 (−0.06)	0.003 (1.10)	1.84E-05 (0.01)
SMC	−0.001 (−0.62)	−0.001 (−0.86)	−0.001 (−1.41)	−0.001*** (−3.73)	−0.005* (−1.93)	−0.001*** (−5.20)
POP				0.932*** (7.00)	1.373*** (9.53)	1.002*** (13.12)
Adj R^2	0.88	0.99	0.89	0.99	0.99	0.88

Note: (***), (**) and (*) indicate that the test statistics is significant at 1%, 5% and 10% levels, respectively. Elasticities are based on fully modified least squares (FMOLS), dynamic least squares (DLOS) and generalized method of moments (GMM) techniques, respectively. For GMM, the 2SLS instrument weighting matrix is employed. t-values are provided in the parentheses. For Wald χ^2 tests, p-values are provided in parentheses.

TABLE 8 KMS (2014) threshold nonlinear model of cross-sectional dependence for REC and CO_2 using lagged independent variables.

Elasticities	Model I	Model II
PI_{t-1}	−0.8312*** (−4.5823)	0.0934*** (4.0910)
IQ_{t-1}	0.0777*** (9.1499)	
REC_{t-1}		−0.7070* (1.6825)
FDI_{t-1}	0.0685*** (5.1383)	−0.0294*** (−7.1991)
SMC_{t-1}	−10.6907*** (−5.0081)	−0.1474 (1.1128)
POP_{t-1}		−10.9523*** (−5.0940)
r	0.0275	0.185
ρ	−0.5792*** (−4.3723)	−0.6182*** (−6.0570)

Note: These are the PCCE-KMS estimators proposed by Pesaran (2006) where ft = { t, t}. r and ρ are the threshold and the spatial autoregressive parameters. (***), (**) and (*) indicate that the test statistics is significant at 1%, 5% and 10% levels, respectively.

$$\begin{aligned}\Delta \mathrm{REC}_{i,t} = {} & \Big[a_{11}\Delta \mathrm{PI}_{i,t} + a_{12}\Delta \mathrm{IQ}_{i,t} + a_{13}\Delta \mathrm{FDI}_{i,t} \\ & + a_{14}\Delta \mathrm{SMC}_{i,t}\Big]\ell(\Delta \mathrm{REC}_{i,t} \le 2005) + \Big[a_{15}\Delta \mathrm{PI}_{i,t} \\ & + a_{16}\Delta \mathrm{IQ}_{i,t} + a_{17}\Delta \mathrm{FDI}_{i,t} \\ & + a_{18}\Delta \mathrm{SMC}_{i,t}\Big]\ell(\Delta \mathrm{REC}_{i,t} > 2005) + v_{1,i,t}\end{aligned} \tag{3}$$

$$\begin{aligned}\Delta \mathrm{CO}_{2,i,t} = {} & \Big[c_{11}\Delta \mathrm{POP}_{i,t} + c_{12}\Delta \mathrm{PI}_{i,t} + c_{13}\Delta \mathrm{REC}_{i,t} \\ & + c_{14}\Delta \mathrm{FDI}_{i,t} + c_{15}\Delta \mathrm{SMC}_{i,t}\Big]\ell(\Delta \mathrm{CO}_{2,i,t} \le 2005) \\ & + \Big[c_{16}\Delta \mathrm{POP}_{i,t} + c_{17}\Delta \mathrm{AFL}_{i,t} + c_{18}\Delta \mathrm{MGR}_{i,t} \\ & + c_{19}\Delta \mathrm{FDI}_{i,t} + c_{20}\Delta \mathrm{SMC}_{i,t}\Big]\ell(\Delta \mathrm{CO}_{2,i,t} > 2005) \\ & + v_{1,i,t}\end{aligned} \tag{4}$$

where $\ell(.)$ is the indicator function and other variables follow earlier definitions. The estimated regime-based results are consistent with previous findings.[4]

In summary, the empirical results of this study using long-run estimates showed that institutional quality and stock markets played a crucial role in increasing renewable energy use. Further, these findings confirmed that the FDI inflows, stock market growth and renewable energy consumption contribute to environmental quality by reducing the growth of CO_2 emissions in the OECD economies.

5 | POLICY IMPLICATIONS

Given the growing concerns around the issues of climate change and environmental degradation, policymakers and government officials around the globe are paying considerable attention to the mitigating factors of these issues. One important factor that causes environmental degradation is the use of fossil fuels; therefore, several countries have initiated policies to encourage renewable energy use across various economic and commercial activities. Despite that, many countries could not meet their expected renewable energy generation and consumption targets. This might be due to the lack of strong institutional support for renewable energy projects. More precisely, the institutional quality could be central to the renewable energy sector by initiating appropriate policies. For instance, the strong institutions will not only provide financial and other subsidies to the renewable energy firms but may also create a market for renewable energy. Therefore, institutional support is vital for any country's growth of renewable energy. Given this backdrop, this study has empirically investigated the role of institutional quality on renewable energy consumption in 18 OECD nations and offered the following important policy implications.

First, the finding suggests that improving institutional quality is crucial in enhancing renewable energy consumption. A strong institutional setup is essential for every country to take necessary actions to mitigate pollution growth by initiating several policy actions to inspire the production and use of renewable energy in various economic activities. In addition, the role of institutional quality in promoting renewable energy consumption has become more important during crises, such as the COVID-19 pandemic and the Russian-Ukraine war. During these challenging periods, energy markets have become highly volatile, affecting investments and returns of renewable energy projects (Miah et al., 2023). However, high-quality institutions are expected to provide stable and predictable policy environments during the crisis, including subsidies, tax incentives and renewable energy targets, that help attract investments and provide confidence to renewable energy developers.

In the context of developing countries, many developing nations have unstable political systems with poor institutional setups. Further, developing economies are trapped with high poverty levels, unemployment and economic disparities. Therefore, as expected, the main focus of these countries is to address their basic economic issues rather than environmental issues, as suggested by the environmental Kuznets curve (EKC) hypothesis. The proponents of the EKC hypothesis (Grossman & Krueger, 1991; Shafik & Bandyopaddhya, 1992) suggest that economic development initially worsens the environment as the government has to prioritize poverty and other basic human needs. However, economic growth improves environmental quality after a certain threshold income level. Given that, the low institutional quality and high poverty level are the main reasons developing economies pay less attention to renewable energy and environmental issues. In this connection, it can be emphasized that the economic growth in many developing countries has slowed down during COVID-19 and the Russian-Ukraine war, which may negatively affect the clean energy transition. Therefore, leaders from developing countries must take the initiative to implement necessary policies to encourage renewable energy consumption by strengthening their institutions.

Second, the findings of this study also indicate that the stock market growth also positively contributes to renewable energy promotions. Given this evidence, this study recommends that the policymakers of the OECD countries should strengthen their institutions to facilitate further policies that encourage investors to invest in green equities and bonds. This recommendation has become more crucial during the current crises of post-COVID-19 and the Russian-Ukraine war when investors seek protection to commit to investment. Institutional quality, which includes low levels of corruption and strong legal frameworks, fosters investor confidence to obligate investment in renewable energy projects.

Finally, the findings indicate that the rise in per capita income promotes renewable energy use. This finding is the impetus in the current context to combat the cost of living and energy crisis due to COVID-19 and the Russian-Ukraine war that affluent households should invest in cheap, home-grown renewable energy to reduce their energy bills.

6 | CONCLUSION

This study investigates the impact of institutional quality on renewable energy consumption in 18 OECD economies across the world. Employing a large panel dataset, the robust panel unit root tests identify that all variables in our models have an identical order of integration, suggesting that they are nonstationary at their levels but stationary at the first-order differences. The panel cointegration test with structural breaks and cross-section dependence shows there is a long-run equilibrium relationship between institutional quality, renewable energy consumption and control variables. The long-run estimations under KMS (2014) threshold nonlinear model display that better institutional quality has a significant and positive influence on increasing renewable energy consumption.

This study makes a number of contributions to policy, practice and literature. Specifically, it is proved that institutional quality has a significant role in promoting renewable energy uses, while FDI, stock markets and renewable energy use have a reducing effect on CO_2 emissions. Given these findings, the OECD economies should further strengthen their institutional setup to promote renewable energy generation and consumption. Moreover, these countries also use their financial institutions to improve transparency in terms of the type of energy used by the firms and their contribution to environmental degradation and sustainability. This motivates listed firms to adopt more environmentally sustainable practices in their operations, further enhancing environmental sustainability. The findings of this study are also crucial during crises like COVID-19 and the Russian-Ukraine war. High-quality institutions that deliver stability, support and transparency are critical in appealing investments, nurturing public support and safeguarding renewable energy projects during challenging times. Finally, this study adds new knowledge to the empirical literature on the effect of institutional quality on renewable energy promotions.

While this study explores the role of institutions in promoting renewable energy consumption, it also creates new avenues for future research in the area of sustainable development. Firstly, future studies may focus on developing countries with significantly higher political instability and turbulence than in OECD countries. In this vein, comparative studies between developed and developing countries might provide relevant policy options. Secondly, due to the limitation of long-time series data, this study employs robust panel econometric techniques that provide general findings for OECD economies. Nevertheless, future research may conduct country-specific investigations if long-time series data become available to derive more precise findings and recommendations for a particular economy and sector (Shafiq et al., 2019). Thirdly, on the other hand, studies can be conducted at the microlevel to assess the competence level (Hafeez & Essmail, 2007) and technology absorption capacity (Hussain & Hafeez, 2008) in a particular economy to use renewable energy technologies best. Lastly, the COVID-19 pandemic also laid bare the massive, widening, disparity in institutional quality across nations (Aizenman et al., 2022; Rodríguez-Pose & Burlina, 2021). When the data (especially regarding institutional quality and renewable energy consumption) become available, the relationships between institutional quality, renewable energy use and CO_2 emissions in the OECD economies may be worth revisiting.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest among authors.

DATA AVAILABILITY STATEMENT

All data are collected from publicly available sources.

ORCID

Md. Samsul Alam https://orcid.org/0000-0001-7796-7445

ENDNOTES

[1] The institutional quality or economic freedom index data was available once in five years until the year 2000. Therefore, we use linear interpolation technique to generate the unavailable data in the sample period.

[2] The FDI data were negative for some of the sample countries for some years. As a result of that, it would be difficult to convert the FDI series into natural logarithms. Therefore, we have added a constant numeric value to the FDI series before we convert it to the natural logarithms.

[3] For brevity, these results are not presented in the paper. However, they will be made available if required.

[4] These results are not reported here due to space limitations. However, these findings are readily available upon request.

REFERENCES

Aguirre, M., & Ibikunlee, G. (2014). Determinants of renewable energy growth: A global sample analysis. *Energy Policy*, *69*, 374–384.

Aizenman, J., Cukierman, A., Jinjarak, Y., Nair-Desai, S., & Xin, W. (2022). Gaps between official and excess Covid-19 mortality measures: The effects of institutional quality and vaccinations. *Economic Modelling*, *116*, 105990. https://doi.org/10.1016/j.econmod.2022.105990

Alam, M. S., Apergis, N., Paramati, S. R., & Fang, J. (2021). The impacts of R&D investment and stock markets on clean-energy consumption and CO_2 emissions in OECD economies. *International Journal of Finance & Economics*, *26*(4), 4979–4992.

Alam, M. S., Safiullah, M., & Islam, M. S. (2022). Cash-rich firms and carbon emissions. *International Review of Financial Analysis*, *81*, 102106.

Apergis, N., & Payne, J. E. (2010a). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy*, *38*(1), 656–660.

Apergis, N., & Payne, J. E. (2010b). Renewable energy consumption and growth in Eurasia. *Energy Economics*, *32*(6), 1392–1397.

Atif, M., Hossain, M., Alam, M. S., & Goergen, M. (2021). Does board gender diversity affect renewable energy consumption? *Journal of Corporate Finance*, *66*, 101665.

Bai, J., & Ng, S. (2004). A PANIC attack on unit roots and cointegration. *Econometrica*, *72*(4), 1127–1177.

Banerjee, A., & Carrion-i-Silvestre, J. L. (2013). Cointegration in panel data with structural breaks and cross-section dependence. *Journal of Applied Econometrics*, *30*, 1–23.

Banerjee, R., Gupta, K., & McIver, R. (2019). What matters most to firm-level environmentally sustainable practices: Firm–specific or country–level factors? *Journal of Cleaner Production*, *218*, 225–240.

Bird, L., Bolinger, M., Gagliano, T., Wiser, R., Brown, M., & Parsons, B. (2005). Policies and market factors driving wind power development in the United States. *Energy Policy*, *33*(11), 1397–1407.

Breitung, J. (2000). The local power of some unit root tests for panel data. In B. Baltagi (Ed.), *Nonstationary panels, panel cointegration, and dynamic panels* (pp. 161–178). JAI Press Advances in Econometrics, 15.

Candau, F., & Dienesch, E. (2017). Pollution haven and corruption paradise. *Journal of Environmental Economics and Management*, *85*, 171–192.

Carley, S. (2009). State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy*, *37*(8), 3071–3081.

Carrión-i-Silvestre, J. L., Barrio, T. D., & Lopez-Bazo, E. (2005). Breaking the panels. An application to the GDP per capita. *The Econometrics Journal*, *8*, 159–175.

Chen, Y. (2018). Factors influencing renewable energy consumption in China: An empirical analysis based on provincial panel data. *Journal of Cleaner Production*, *174*, 605–615.

da Silva, P. P., Cerqueira, P. A., & Ogbe, W. (2018). Determinants of renewable energy growth in sub-Saharan Africa: Evidence from panel ARDL. *Energy*, *156*, 45–54.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366), 427–431.

Dietz, T., & Rosa, E. A. (1994). Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review*, *1*(2), 277–300.

Dietz, T., & Rosa, E. A. (1997). Effects of population and affluence on CO_2 emissions. *Proceedings of the National Academy of Sciences*, *94*(1), 175–179.

Dollar, D., & Kraay, A. (2003). Institutions, trade, and growth. *Journal of Monetary Economics*, *50*(1), 133–162.

Emirmahmutoglu, F., & Omay, T. (2014). Reexamining the PPP hypothesis: A nonlinear asymmetric heterogeneous panel unit root test. *Economic Modelling*, *40*, 184–190.

Enders, W., & Granger, C. W. J. (1998). Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates. *Journal of Business & Economic Statistics*, *16*(3), 304–311.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, *55*(2), 251–276.

Fatas, A., & Mihov, I. (2013). Policy volatility, institutions, and economic growth. *Review of Economics and Statistics*, *95*(2), 362–376.

Frees, E. W. (1995). Assessing cross-sectional correlation in panel data. *Journal of Econometrics*, *69*(2), 393–414.

Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, *32*(200), 675–701.

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.

Gan, J., & Smith, C. T. (2011). Drivers for renewable energy: A comparison among OECD countries. *Biomass and Bioenergy*, *35*(11), 4497–4503.

Gennaioli, C., & Tavoni, M. (2016). Clean or dirty energy: Evidence of corruption in the renewable energy sector. *Public Choice*, *166*(3–4), 261–290.

Gregory, A. W., & Hansen, B. E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics*, *70*(1), 99–126.

Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of the North American free trade agreement (NBER working paper 3914)*. National Bureau of Economic Research. https://doi.org/10.3386/w3914

Hafeez, K., & Essmail, E. A. (2007). Evaluating organisation core competences and associated personal competencies using analytical hierarchy process. *Management Research News*, *30*(8), 530–547.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of Econometrics*, *93*(2), 345–368.

Hussain, Z., & Hafeez, K. (2008). Changing attitudes and behavior of stakeholders during an information system-let organizational change. *The Journal of Applied Behavioral Science (JABS)*, *44*(4), 490–513.

IEA. (2021). *Key world energy statistics 2021*. International Energy Agency. Available at https://iea.blob.core.windows.net/assets/52f66a88-0b63-4ad2-94a5-29d36e864b82/KeyWorldEnergyStatistics2021.pdf

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53–74.

Ince, D., Vredenburg, H., & Liu, X. (2016). Drivers and inhibitors of renewable energy: A qualitative and quantitative study of the Caribbean. *Energy Policy*, *98*, 700–712.

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.

Kapetanios, G., Mitchell, J., & Shin, Y. (2014). A nonlinear panel data model of cross-sectional dependence. *Journal of Econometrics*, *179*(2), 134–157.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. *Energy for Sustainable Development*, *31*, 83–90.

Kutan, A. M., Paramati, S. R., Ummalla, M., & Zakari, A. (2018). Financing renewable energy projects in major emerging market economies: Evidence in the perspective of sustainable economic development. *Emerging Markets Finance and Trade*, *54*(8), 1762–1778.

Lee, J. W. (2013). The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. *Energy Policy*, *55*, 483–489.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, *108*(1), 1–24.

Li, H., Mu, H., Zhang, M., & Li, N. (2011). Analysis on influence factors of China's CO2 emissions based on path–STIRPAT model. *Energy Policy*, *39*(11), 6906–6911.

Lin, B., Omoju, O. E., & Okonkwo, J. U. (2016). Factors influencing renewable electricity consumption in China. *Renewable and Sustainable Energy Reviews*, *55*, 687–696.

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics*, *61*, 631–652.

Marques, A. C., Fuinhas, J. A., & Manso, J. P. (2010). Motivations driving renewable energy in European countries: A panel data approach. *Energy Policy*, *38*(11), 6877–6885.

Mehmood, U. (2021). Renewable-nonrenewable energy: Institutional quality and environment nexus in South Asian countries. *Environmental Science and Pollution Research*, *28*(21), 26529–26536.

Menegaki, A. N. (2011). Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis. *Energy Economics*, *33*(2), 257–263.

Miah, M. D., Shafiullah, M., & Alam, M. S. (2023). The effect of financial stress on renewable energy consumption: Evidence from US data. *Environment, Development and Sustainability*, 1–24.

Ng, S., & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, *69*(6), 1519–1554.

OECD. (2015). *Building more effective, accountable, and inclusive institutions for all*. Organisation for Economic Co-operation and Development (OECD). Available at https://www.oecd.org/dac/_POST-2015%20effective%20and%20accountable%20institutions.pdf

OECD. (2018). *Renewable energy*. Organisation for Economic Co-operation and Development (OECD). Available at https://data.oecd.org/energy/renewable-energy.htm

Ohler, A., & Fetters, I. (2014). The causal relationship between renewable electricity generation and GDP growth: A study of energy sources. *Energy Economics*, *43*, 125–139.

Omri, A., & Nguyen, D. K. (2014). On the determinants of renewable energy consumption: International evidence. *Energy*, *72*, 554–560.

Paramati, S. R., Alam, M. S., & Apergis, N. (2018). The role of stock markets on environmental degradation: A comparative study of developed and emerging market economies across the globe. *Emerging Markets Review*, *35*, 19–30.

Paramati, S. R., Alam, M. S., Hammoudeh, S., & Hafeez, K. (2021). Long-run relationship between R&D investment and environmental sustainability: Evidence from the European Union member countries. *International Journal of Finance & Economics*, *26*(4), 5775–5792.

Paramati, S. R., Apergis, N., & Ummalla, M. (2017). Financing clean energy projects through domestic and foreign capital: The role of political cooperation among the EU, the G20 and OECD countries. *Energy Economics*, *61*, 62–71.

Paramati, S. R., Ummalla, M., & Apergis, N. (2016). The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies. *Energy Economics*, *56*, 29–41.

Pedroni, P. (2001). Fully modified OLS for heterogeneous cointegrated panels. In *Nonstationary panels, panel cointegration, and dynamic panels* (pp. 93–130). Emerald Group Publishing Limited.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. (Cambridge Working Papers in Economics No. 0435), Faculty of Economics, University of Cambridge.

Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, *74*(4), 967–1012.

Philips, P. C. B., & Perron, P. (1988). Testing for unit roots in time series regression. *Biometrika*, *75*, 335–346.

Popp, D., Hascic, I., & Medhi, N. (2011). Technology and the diffusion of renewable energy. *Energy Economics*, *33*(4), 648–662.

Rafiq, S., Bloch, H., & Salim, R. (2014). Determinants of renewable energy adoption in China and India: A comparative analysis. *Applied Economics*, *46*(22), 2700–2710.

Rahman, M. M., & Sultana, N. (2022). Impacts of institutional quality, economic growth, and exports on renewable energy: Emerging countries perspective. *Renewable Energy*, *189*, 938–951.

Reboredo, J. C. (2015). Is there dependence and systemic risk between oil and renewable energy stock prices? *Energy Economics*, *48*, 32–45.

Rodríguez-Pose, A., & Burlina, C. (2021). Institutions and the uneven geography of the first wave of the COVID-19 pandemic. *Journal of Regional Science*, *61*(4), 728–752.

Sadorsky, P. (2009a). Renewable energy consumption, CO_2 emissions and oil prices in the G7 countries. *Energy Economics*, *31*(3), 456–462.

Sadorsky, P. (2009b). Renewable energy consumption and income in emerging economies. *Energy Policy*, *37*(10), 4021–4028.

Salim, R. A., & Rafiq, S. (2012). Why do some emerging economies proactively accelerate the adoption of renewable energy? *Energy Economics*, *34*(4), 1051–1057.

Sardianou, E., & Genoudi, P. (2013). Which factors affect the willingness of consumers to adopt renewable energies? *Renewable Energy*, *57*, 1–4.

Schaffer, L. M., & Bernauer, T. (2014). Explaining government choices for promoting renewable energy. *Energy Policy*, *68*, 15–27.

Shafik, N., & Bandyopadhyay, S. (1992). Economic growth and environmental quality: Time series and cross-country evidence. Background Paper for the World Development Report, The World Bank, Washington, DC.

Shafiq, M., Lasrado, F., & Hafeez, K. (2019). The effect of TQM on organisational performance: Empirical evidence from the textile sector of a developing country using SEM. *Total Quality Management & Business Excellence*, *30*(1–2), 31–52.

Shafiullah, M., Miah, M. D., Alam, M. S., & Atif, M. (2021). Does economic policy uncertainty affect renewable energy consumption? *Renewable Energy*, *179*, 1500–1521.

Shafiullah, M., Papavassiliou, V. G., & Shahbaz, M. (2021). Is there an extended education-based environmental Kuznets curve? An analysis of US states. *Environmental and Resource Economics*, *80*, 795–819.

Shahbaz, M., Shafiullah, M., Papavassiliou, V. G., & Hammoudeh, S. (2017). The CO2–growth nexus revisited: A nonparametric analysis for the G7 economies over nearly two centuries. *Energy Economics*, *65*, 183–193.

Smith, M. G., & Urpelainen, J. (2014). The effect of feed-in tariffs on renewable electricity generation: An instrumental variables approach. *Environmental and Resource Economics*, *57*, 367–392.

Stadelmann, M., & Castro, P. (2014). Climate policy innovation in the South – Domestic and international determinants of renewable energy policies in developing and emerging countries. *Global Environmental Change*, *29*, 413–423.

UNFCC. (2018). *The Paris agreement*. United Nations Framework Convention on Climate Change. Available at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Uzar, U. (2020). Is income inequality a driver for renewable energy consumption? *Journal of Cleaner Production*, *255*, 120287.

Van Ruijven, B., & Van Vuuren, D. P. (2009). Oil and natural gas prices and greenhouse gas emission mitigation. *Energy Policy*, *37*(11), 4797–4808.

Wang, E., Gozgor, G., Mahalik, M. K., Patel, G., & Hu, G. (2022). Effects of institutional quality and political risk on the renewable energy consumption in the OECD countries. *Resources Policy*, *79*, 103041.

Wang, P., Wu, W., Zhu, B., & Wei, Y. (2013). Examining the impact factors of energy-related CO2 emissions using the STIRPAT model in Guangdong Province, China. *Applied Energy*, *106*, 65–71.

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and Statistics*, *69*(6), 709–748.

World Bank. (2018). *Helping countries combat corruption: The role of the World Bank*. The World Bank. Available at http://www1.worldbank.org/publicsector/anticorrupt/corruptn/cor06.htm

Yin, H., & Powers, N. (2010). Do state renewable portfolio standards promote in-state renewable generation?. *Energy Policy*, *38*(2), 1140–1149.

York, R., Rosa, E. A., & Dietz, T. (2003). STIRPAT, IPAT and ImPACT: Analytic tools for unpacking the driving forces of environmental impacts. *Ecological Economics*, *46*(3), 351–365.

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