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RESEARCH ARTICLE

Which factors influence the decisions of renewable energy investors? Empirical evidence from OECD and BRICS countries

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Abstract
The importance of using renewable energy (RE) sources has increased significantly in recent times, especially considering the growing concerns about climate change problems and rising fossil fuel prices, which pose a significant threat to the national economies. Therefore, empirical studies that can be used both domestically and internationally in harmony can be created in line with rising investments in RE. However, there has no more analysis of RE investments from the viewpoint of investors in the literature up to this point, and it is crucial to highlight the best investor practices when deploying RE. This research provides theoretical and empirical support for the factors influencing RE investments; used in this analysis are newly constructed panel data on 34 OECD countries and the 5 BRICS countries that range from 2000 to 2020. Specifically, the generalized moment method (GMM), robustness check, fixed and random effects models, panel unit testing, and other panel regression techniques were employed in the study to analyze the determinants of RE investment. The main findings of this paper suggest that economic growth, RE policy, and R&D expenditures all have a statistically significant and positive relationship with RE capacity. Furthermore, RE investment is inversely relative to energy use, electricity use, and carbon (CO_2) emissions. As a result, rigorous governmental or state regulation (policy, R&D) is essential for RE investment.

Keywords Renewable energy · RE investment and policies · Climate change · OECD and BRICS countries

Introduction

Investments in RE sources are gaining popularity as a viable way for governments to achieve energy independence while also stimulating economic growth. Masini and Menichetti (2012) look into the decision-making process that goes into investing in RE sources. They investigated behavioral factors influencing RE investment decisions and the relationship between RE investments and portfolio performance using a conceptual model and an empirical study. They should choose additional policies to stimulate the investment of renewable resources, since policy instruments, particularly those relevant to investment decisions, have a significant impact on investment decisions. The findings also show that some investors have very distinct investment strategies. One sort of investor likes short-term incentives and is more driven to invest based on short-term policy incentives that have a higher possibility for instant profit. Other investors take a longer-term approach. They prefer policy incentives that yield a lower return on investment over a longer period, as long as the policy ensures the long-term support (Masini and Menichetti, 2012; Bushee, 1998; Hirshleifer, 1993).

In order for the RE investment policy to be successful, it must satisfy its main stakeholders (Bryson, 2004). It identified potential investors as relevant stakeholders who make a crucial difference in the public policy efficacy of RE investment targets, using the logic of stakeholder identification given by Mitchell et al. (1997) and adapting it to the context of RE. However, concerning the relationship between investor behavior and RE investment, there is a lack of a comprehensive theoretical and empirical framework. Based on the literature, this research creates an investor perspective framework, which is then put to the test through an empirical investigation. To put it another way, the current study

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draws on existing knowledge of RE investment, develops a new conceptual framework to guide policy, and tests the generated conceptual model using quantitative methodologies. The goal of this paper is to provide major insights into the establishment of successful RE policies, focusing specifically on RE investment in OECD and BRICS countries, in order to shed light on the relationship between investor behavior and RE outcomes. The following is the research question addressed in this paper: *which factors influence the renewable energy investors' decision?*

sThe paper makes manifold contributions to the literature. First, by offering a better knowledge of investor behavior toward RE resources, the study helps RE investors by proposing a conceptual model for designing effective policy instruments that should overcome impediments in their way. Second, the current research makes a methodological addition by identifying the characteristics that are beneficial in RE investments using empirical analysis in a wide range of countries. Third, this is the first attempt in the literature to include the OECD and BRICS countries in the empirical study, with data that is current and collected over a long period, as well as RE deployment from the investor's perspective. As a result, the publication contributes to the legitimacy of the research. Therefore, the paper contributes to the validity of the findings being extended to a broader and more comprehensive setting. In this paper, we endeavor to provide a greater understanding of the linkage between economic growths, policies, R&D, CO_2 emissions, energy, and electricity consumption with RE capacity. It thus made the variables that affect RE investments apparent.

The following is how the rest of the paper is organized: The second part is a review of the literature. The current paper's method and data are described in the third part. This entails presenting the conceptual foundation and doing quantitative research. The empirical findings and debate are presented in the next part, followed by concluding remarks as policy recommendations.

Literature review

An emerging body of literature has looked into how policies should be crafted to efficiently mobilize investments in the RE sector (Menichetti, 2010). Despite this enormous effort, knowledge of RE investment and the variables linked with RE policy is still inadequate. While various studies have presented policy efficacy measures (Masini and Menichetti, 2012; Musango and Brent, 2011; Wüstenhagen and Menichetti, 2012), they only provide a restricted view of investors' opinions. As noted in the political economics literature, a key flaw in current research is the lack of attention on investors' perspectives (Lipp, 2007; Masini and Menichetti, 2012; Musango and Brent, 2011; Wüstenhagen and Menichetti, 2012).

Most of the research focuses on investor behavior as a barrier to RE investments (Niesten et al. 2018; Salm et al. 2016; Nasirov et al. 2015; Leete et al. 2013; Masini and Menichetti 2012; Masini and Menichetti, 2010; Wüstenhagen et al. 2007). Nasirov et al. (2015) explore the barriers to the adoption of RE sources from the investor's perspective. Grid connection constraints and a lack of grid capacity, long permit processing times, certainty of land and/or water leases, and limited access to finance are among the most significant barriers to RE projects, according to the research. Leete et al. (2013) intend to uncover common hurdles and incentives to investing in RE through a series of in-depth interviews with people in the field. Because of their inability to predict costs and the time required to develop RE technologies, investors/stakeholders do not have the option to re-invest in RE, according to the findings. Masini and Menichetti (2012) look at the decision-making process that goes into investing in RE solutions.

The lack of government/state-based subsidies is another impediment to RE projects (Tura et al. 2019; Jones, 2015; Lilliestam and Patt, 2015; Kostka et al. 2013; Shill et al. 2012). De Jongh et al. (2014) point out that South Africa has a lack of clear regulations and government support. According to several studies, the most significant RE is cost. Malik et al. (2019) for GCC countries, Hu et al. (2018), Fashina et al. (2018) for Uganda, Yuosoff and Kardooni (2012) for Malaysia, and Mostert (2009) for Nicaragua are just a few examples. Furthermore, Painuly (2001) investigates RE energy companies face several challenges, including a lack of pre-financing, credit facilities, and technical competence.

RE investors are often treated in one of two ways in the literature. One way is as a homogeneous group of utility-type actors investing with profit maximization in mind (Bergek et al. 2013; Gross et al. 2010; Koo et al. 2011), and investors in RE often base their judgments on comparisons of various electricity producing methods. Other research defines RE investors as a varied set of participants that includes small- and medium-sized private investors, independent power producers, and cooperatives (Agterbosch et al., 2004; Loock, 2012). Because of the hazards associated with fossil fuels, such as price volatility, import availability, and the cost of domestic economic exposure, investing in RE sources may be more appealing than investing in fossil fuels. RE sources are essentially homegrown energy supplies that are not dependent on the availability and pricing of imported energy based on global markets. Uncertainties in RE policies, prices, and regulations, on the other hand, can raise degrees of investment risk and uncertainty, making renewable investments less appealing than uncertain fossil-based sources (Finon and Perez, 2007; Popp et al. 2011).

OECD countries rank first in terms of CO_2 emissions compared to other regions. In 2018, OECD countries emitted an average of 8.7 tons of CO_2 emissions per capita, while the rest of the world released 4.3 tons of CO_2 emissions (OECD, 2020). Therefore, increasing the proportion of RE investments is required to create a low-carbon society (Polzin et al. 2015). A greater investment in the RE industry has been seen across the OECD countries. Germany, the USA, Japan, and theUK, for example, were the top investors in 2013. OECD countries have several priorities for attaining global CO_2 emissions target, including reducing energy imports, expanding RE technologies, and lowering CO_2 emissions. Belgium, Denmark, and Germany have projected a 100% RE share by 2050 to reach these targets (Sisodia et al. 2015; Klaus et al. 2010).

BRICS countries have abundant RE sources; however, they largely employ carbon-intensive energy sources (Zeng et al. 2017). China, for example, has abundant wind resources (Meisen and Hawkins, 2009), whereas India and South Africa have ideal conditions for solar energy development (Nautiyal, 2012; Mulaudzi and Bull, 2016). There are several water resources in Brazil that are ideal for the construction of hydroelectric power facilities (Meisen and Hubert, 2010). Russia exports and uses a lot of fossil fuels every year, but it also possesses a lot of RE sources with a lot of promise (Kirsanova et al. 2018; Cherepovitsyn and Tcvetkov, 2017; Pristupa and Mol, 2015). However, information on the impact of investor behavior on RE implementation is limited. To our knowledge, no research has been done on the development of a conceptual model for the structural and behavioral factors that influence RE investor decisions, as well as the empirical testing of this model for OECD and BRICS nations. Besides these aforementioned studies, the paper has provided further detail for the literature review in the Appendix section, Table 8.

Data and method

To begin, a conceptual model was proposed within the context of the relevant literature in order to construct a conceptual framework, and the paper formed hypotheses based on the models' goals. Then, for the 34 OECD and 5 BRICS countries, a country-level panel data analysis of RE investments was done for the period 2000–2020.

Conceptual framework analysis from investors' perspectives

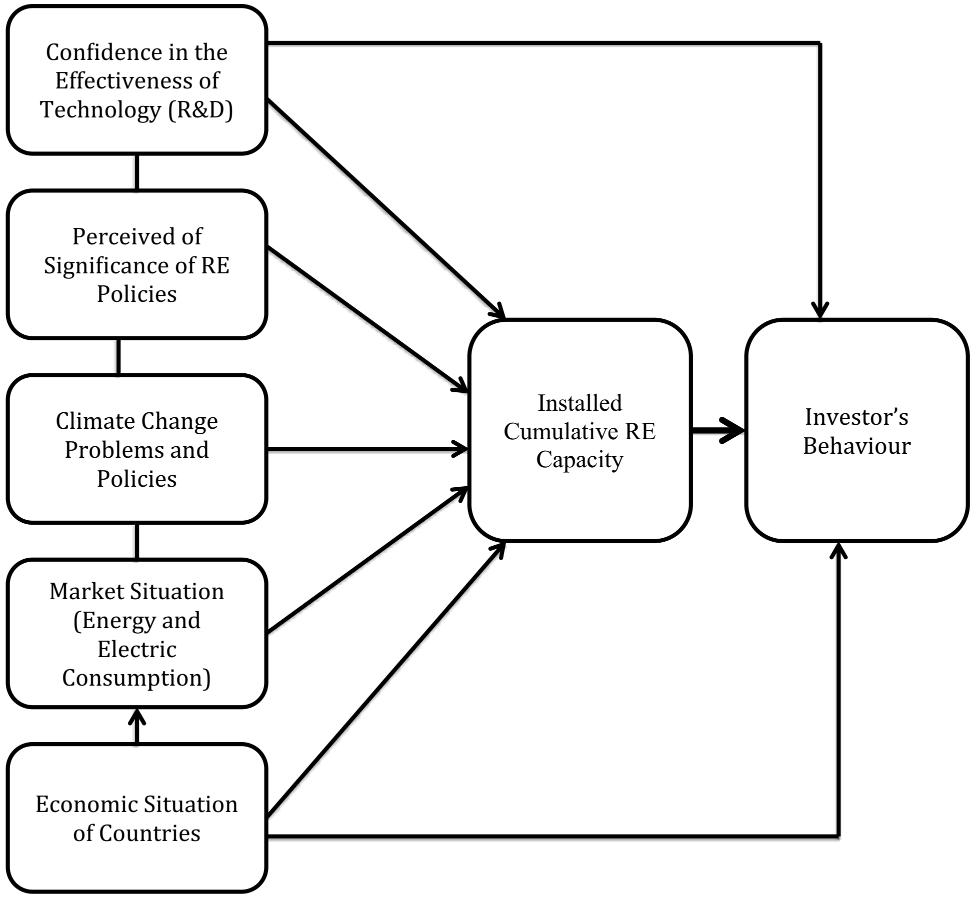
Academic and political debates have centered on what should be done to deploy renewable investments (RE projects) (Polzin et al. 2015; Bergek et al. 2013; Wüstenhagen and Menichetti, 2012). High upfront costs, risks and long-term viability of technology, long payback periods, high regulatory and infrastructure dependency, and uncertainty about public acceptance are all factors influencing investor investments in RE deployment (Rodrguez et al. 2014; Haley and Schuler, 2011; Muller et al. 2011). These characteristics are important drivers in real estate investments, and they have a direct impact on RE investors' risk and return.

The ultimate goal of a sustainable RE strategy is to lower the capital costs of RE technology by government subsidies, creating fair competition for both fossil fuel-based and RE technologies (Polzin et al. 2015). As a result, policymakers should base their decisions on the issues that affect RE investors. According to Bergek et al. (2013), policymakers make judgments about risk regulation and administrative processes based on the insights of RE project developers (Friebe et al. 2014). Similarly, Chassot et al. (2014) place a premium on the perceived risk posed by policies, which is one of the most significant factors influencing RE investment decisions.

The essential parts of RE investor decision-making are traced in a conceptual analysis based on prior work on renewable investment, which develops the theoretical framework of renewable investment. The conceptual model (Zahra, 1993) is more sophisticated for assessing strategic options for RE investment, and it serves as a framework for comprehending this research and a starting point for identifying relevant study topics (Ata, 2015). Arguments such as property rights protection and the capacity to import materials are expected to play a role here. It also includes a diagram of the suggested conceptual framework for the linkages between RE market investment and variables. There is a dependent variable, installed cumulative RE capacity, and the paper has suggested an econometric model to solve the major research question. The present paper depicts the conceptual model for this investigation in Fig. 1.

A variety of factors affects installed cumulative RE capacity, including technological efficacy, RE regulations, climate policies/problems, market conditions, and country economic conditions, all of which influence investor behavior.

Fig. 1 Conceptual framework



The paper refers to the availability of financial expenditures on renewable technologies for sustainable RE project encouragement as R&D capacity risk. The budget for R&D must be raised in order for RE investments to increase (Kul et al. 2020; Chu and Majumdar, 2012). Renewable and climate policy are one of the most significant factors in expanding RE investments. As a result, politicians must establish clear and suitable long-term RE policies to assist investors in incorporating climate change concerns and allocating money to low-carbon technology (He et al. 2019; Masini and Menichetti, 2012; Reuter et al. 2012). In the energy industry, rising power and energy consumption have prompted many countries, particularly those that import energy, to look for alternate energy sources (Kahia et al. 2017). Finally, rising economic growth leads to more investment in RE sources. According to Chen et al. (2021), in nations where people’s democratic rights are better safeguarded, there is a positive relationship between economic growth and RE capability, whereas in less democratic countries, there is a negative relationship.

The paper empirically investigated the three primary hypothesis proposals to be as follows, based on the literature review described above.

H1: The perceived importance of implemented policies has a big impact on investor behavior and RE investments.
H2: The higher the proportion of RE investments in total investments, the higher the level of R&D and technological efficiency.
H3: Environmental and economic issues influence RE investments.

Data and variable selection

First and foremost, OECD countries were chosen for the study because they include both developed and developing countries, albeit developing countries unquestionably make up a smaller percentage of the group. In order to avoid any inconsistencies in the definition of variables and units of measurement, its statistics are pooled under this umbrella organization. Finally, there are some commonalities and homogeneities among the policies of all OECD nations (Inglesi-Lotz, 2016). BRICS countries were also included in the study. Because BRICS countries, which are in the first place in fossil fuel use and CO_2 emission, also have great potential in RE (Zeng et al. 2017).

Table 1 Summary of the variables used for analysis

Variables	Unit of measurement	Sources
Installed cumulative RE capacity (REC)	Cumulative, in MW	IRENA
GDP per capita (GDP)	Constant 2017 international $	World Bank
Energy consumption (EC)	Percentage %	IRENA
Electricity power consumption (EPC)	KWh per capita	IEA
Renewable policies (REPs)	US Dollar	IEA
R&D	Percentage %	World Bank
CO_2 emission	Tons per capita	World Bank

Twenty years of data, spanning the years 2000 to 2020, were analyzed. Given the fact that, excluding hydroelectricity, roughly 2.7 trillion dollars were invested globally in RE sources between 2010 and 2019, this is over three times and possibly even more than four times the same amount invested in 2000–2009 (Ajadi, et al. 2020). Accessing pre–2000 RE investment statistics for all 34 OECD and 5 BRICS nations is exceedingly challenging.

Annual data from the World Bank, the International RE Agency (IRENA), and the International Energy Agency (IEA) are analyzed using quantitative methodologies (IEA). Installed cumulative RE capacity is used as a dependent variable in this paper, and it is quantified in megawatts (MW). Table 1 summarizes all variables, which are expressed in natural logs.

GDP per capita is calculated using a constant 2017 international US dollar as an indicator of economic development. The economic variable of GDP per capita is commonly used in the literature to examine its impact on RE deployment (Dogan et al. 2021; Nyiwul 2017; Lucas et al. 2016; Wu and Broadstock, 2015). The impact of economic development on the deployment of RE has been studied in many ways. Marques and Fuinhas (2011), for example, discover that GPD has a detrimental impact on RE deployment. Bamati and Raoofi (2020) argue, on the other hand, that GDP plays a role in RE deployment.

Energy consumption is the percentage of total energy use in the industry. According to Rahman et al. (2019), there is a strong and positive relation between RE usage and energy consumption. Qi et al. (2014) discover that economic growth resulted in high energy demand, which has made it easier to accept renewable electricity.

Electricity consumption is measured in megawatt hours (MWh) per capita. Bednarczyk et al. (2021) emphasize that non-household electricity consumption has a negative influence on RE resources in gross final energy consumption. The increase in non-household electricity usage impacts on the decline in RE.

Renewable policies, as well as solar and wind energy feed-in tariff data, are employed. In this policy, the feed-in tariff is calculated in US dollars. Many studies have found that policies have a positive impact on RE development and deployment (Bourcet 2020; Liu et al. 2019; Kilinc-Ata, 2016; Shrimali and Kniefel, 2011; Adelaja et al. 2010). Adedoyin et al. (2020) also stress the importance of policy in the development of renewable technology.

Clean energy R&D is expected to assist RE deployment as a fraction of overall government R&D for RE energy sources. According to Adedoyin et al. (2020), there is a bidirectional relationship between R&D and RE; hence, investment R&D should focus more on long-term success in sustainable energy sources. Wang et al. (2020) show that R&D and policy considerations both contribute to the promotion of RE.

As an environmental variable, CO_2 emissions are measured in tons per capita. CO_2 emissions, according to Nyiwul (2017), have resulted in an increase in RE development. According to Hao and Shao (2021), nations with lower carbon-intensive economies use higher proportions of RE in their total energy consumption. Similarly, Sharif et al. (2021) demonstrate that reducing CO_2 emissions encourages the usage of RE sources. Zafar et al. (2019) highlight that renewable RE helps to improve environmental quality.

Model

A quantitative method was used to test the hypotheses from the conceptual framework. Hypotheses were tested using empirical models to answer the research issue. From 2000 to 2020, the method would use panel data analysis to compile a country-level panel dataset for OECD and BRICS countries. The RE capacity is modeled using explanatory variables as a function:

$$REC_{i,t} = f(GDP_{i,t}, EC_{i,t}, EPC_{i,t}, REP_{i,t}, R\&D_{i,t}, CO2_{i,t}) \quad (1)$$

where $i = 1, \ldots,$ and $t = 2000, \ldots, 2020$. Equation 1 shows relates RE capacity ($REC_{i,t}$), GDP per capita ($GDP_{i,t}$), energy consumption ($EC_{i,t}$), electric power consumption ($EPC_{i,t}$), RE policies ($REP_{i,t}$), research and development ($R\&D_{i,t}$), and carbon emission ($CO2_{i,t}$). Equation 1 depicts the relationship between RE capacity and the explanatory variables as a linear relationship. The RE capacity model's panel data fixed effects regression could be represented as Eq. (2):

$$\begin{aligned} Y_{i,t} = \beta_0 + \beta_1 GDP_{i,t} + \beta_2 EC_{i,t} + \beta_3 EPC_{i,t} \\ + \beta_4 REP_{i,t} + \beta_5 R\&D_{i,t} + \beta_6 CO2_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (2)$$

Table 2 Panel unit root results

Tests	Results	Variables						
		I (0) unit root						
		REC	GDP	EC	EPC	REP	R&D	CO_2
LLC	Statistics	25.0561	1.07355	−5.95230	−2.24346	−2.22841	−8.50488	3.95355
	Prob	1.0000	0.1415	0.0000	0.0124	0.0129	0.0000	1.0000
IPS	Statistics	32.7107	1.16024	−2.75445	−2.28630	−2.15436	−4.35891	9.21060
	Prob	1.0000	0.8770	0.0029	0.0111	0.0156	0.0000	1.0000
ADF	Statistics	2.38740	65.5851	120.205	339.717	84.3336	134.732	22.4472
	Prob	1.0000	0.8409	0.0015	0.0000	0.0312	0.0000	1.0000
PP	Statistics	2.62659	84.5302	128.863	345.394	167.810	130.504	20.7120
	Prob	1.0000	0.2871	0.0003	0.0000	0.0000	0.0000	1.0000
Tests	Results	I (1) unit root						
LLC	Statistics	−1.70975	−3.12788	−23.5704	−26.0043	−21.8347	−20.7843	−15.0819
	Prob	0.0437	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
IPS	Statistics	−2.12585	−6.53014	−20.0169	−22.1564	−16.6522	−22.0332	−16.4365
	Prob	0.0168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ADF	Statistics	132.182	173.605	469.457	628.988	423.198	493.745	391.733
	Prob	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PP	Statistics	128.754	157.807	878.791	1153.25	540.303	843.394	413.461
	Prob	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

*p value < the significance level of 0.1;

**p value < the significance level of 0.05 and 0.1;

***p value < the significance level of 0.01, 0.05, 0.1

Table 3 Estimation results from fixed and random effects models

Dependent variable	REC (installed cumulative RE capacity)					
Explanatory variables	Fixed effects model estimation[a]			Random effects model estimation		
	Coefficient	Standard error	*p*-value	Coefficient	Standard error	*p*-value
GDP	−0.019633	0.044664	0.6604	−0.055385	0.132484	0.6760
EC	0.074423	0.027066	0.0012	−0.143386	0.067211	0.0398
EPC	−0.004263	0.001676	0.0519	−0.032617	0.013348	0.0046
REP	−0.000935	0.003275	0.7754	−0.033690	0.008305	0.0008
R&D	0.007003	0.003403	0.0479	0.020400	0.007284	0.0052
CO_2	−0.076127	0.030003	0.0114	−0.167991	0.076408	0.0338
R-squared		0.813648		0.693023		
Probability (F-statistic)		0.0000000		0.129078		

Standard errors are corrected for country/state-level serial correlation. The variance inflation factor (VIF) was used to check for colinearity between independent variables.

*p value < the significance level of 0.1;

**p value < the significance level of 0.05 and 0.1;

***p value < the significance level of 0.01, 0.05, 0.1

[a]In addition, the study performed weighted least squares (WLS) statistical analysis to get more robust results. The WLS method overcomes the problems of autocorrelation and varying variance from panel data (Javeed et al., 2021). The results of the robustness test confirm the previous panel regression results. The robustness test panel enables data autocorrelation and varying variance to be overcome (Lu and White, 2014; Prokhorov and Schmidt, 2009)

The installed cumulative RE capacity is represented by $Y_{i,t}$, the coefficient of explanatory factors is β, the country fixed effect index is u_i, and the random error term is ω_{it} applied to each country at each year. Because Shrimali and Kneifel (2011) propose that a country's fixed effects are critical for controlling for unobserved heterogeneity to affect RE investment, the study uses a fixed effects model. The dynamic features of the variables are avoided by transforming all data into a natural logarithmic form. The equation's logarithmic form is shown below:

$$Y_{i,t} = \beta_0 + \beta_1 InGDP_{i,t} + \beta_2 InEC_{i,t} + \beta_3 InEPC_{i,t} + \beta_4 InREP_{i,t} + \beta_5 InR\&D_{i,t} + \beta_6 InCO2_{i,t} + \varepsilon_{i,t} \quad (3)$$

Besides the fixed effect model, the random effect method is used to check whether some differences between the variables affect the renewable capacity because this method includes variables that do not change over time (Olanrewaju et al. 2019). Menegaki (2011) also highlights random effects models with homogeneity assumptions. The random effect model is expressed using the following equation:

$$Y_{i,t} = \alpha + \beta_1 InGDP_{i,t} + \beta_2 InEC_{i,t} + \beta_3 InEPC_{i,t} + \beta_4 InREP_{i,t} + \beta_5 InR\&D_{i,t} + \beta_6 InCO2_{i,t} + \mu_{i,t} + \varepsilon_{i,t} \quad (4)$$

i denotes the subscript of an entity ($i=1,\ldots 10$), t shows time ($t=2000,\ldots 0.2020$), α is an unknown intercept and β is a coefficient of explanatory variables, $\varepsilon_{i,t}$ is the error term, and $\mu_{i,t}$ is the random heterogeneity specific to the observation. The Hausman test is then used to determine whether the unique errors are linked to regression. The findings of the Hausman test are used to determine which model is more appropriate (Hausman, 1978). The Hausman test is written like this:

$$p = \left(\beta_{RE} - \beta_{FE}\right) x (\sum FE - \sum RE)^{-1} x \left(\beta_{RE} - \beta_{FE}\right) \quad (5)$$

β_{RE} denotes coefficient estimates from random effect, while β_{FE} is coefficient estimates from fixed effects.$\sum FE$ shows the co-variance matrix of a fixed effect, and $\sum RE$ is the co-variance matrix of a random effect. The H0 hypothesis is accepted, and the random model is selected if the Hausman test result is significant ($p > 0.05$). The H1 hypothesis, indicating that the fixed model is adequate, is accepted if the Hausman test results are statistically insignificant (p 0.05) (Hausman and Taylor, 1981).

Finally, the dynamic GMM (generalized moments method) model developed by Arrellano and Bond (1991) is used. The GMM model was selected for a number of reasons. First, the GMM model, which is frequently used for panel data, consistently produces accurate findings in the presence of "unobserved heterogeneity, simultaneity and dynamic endogeneity" (Ullah et al. 2018). Second, GMM estimators, which do not require many assumptions, start from the moment relations that exist in the model (Ahn et al. 2001). Finally, the difference GMM estimator is designed for small time dimension and large cross sections (Siddiqui and Ahmed, 2013). There are descriptive data for all factors on each measure of installed cumulative RE capacity, as well as a correlation matrix, in the Appendix section. The correlation coefficient indicates that the explanatory variables are highly multicollinearity.

Table 4 Hausman test results for random effects

Test summary	Chi-square statistic	Chi-square	Probability
Cross-section random	7.356853	6	0.0348

Table 5 Estimation results from GMM model

Dependent variable	REC (installed cumulative RE capacity)		
Explanatory variables	Coefficient	Standard error	p-value
GDP	0.067107*	0.009315	0.0000
EC	−0.036121*	0.004213	0.0000
EPC	−0.026330*	0.011304	0.0201
REP	0.026005*	0.001003	0.0000
R&D	0.023241*	0.000571	0.0000
CO_2	−0.236776*	0.018699	0.0000

*$p < 0.05$

Results and discussion

All variables were verified for stationary using the Levin, Lin, and Chu (LLC) (Levin et al. 2002), Im, Pesaran, Shin (IPS) (Im et al. 2003), ADF-Fisher Chi square (ADF) (Dickey and Fuller, 1979), and PP-Fisher Chi square (PP) (Phillips and Perron, 1988) techniques. At both the I(0) and I(1) levels, Table 2 displays the unit root results for all the data.

As seen in Table 2, all variables are stationary at the first level, and to avoid spurious regression, a first-order unit root test was used in the study. As a result, for the investigated countries, all exogenous variables have become stationary, and a regression analysis is conceivable. Table 3 summarizes the results of numerous estimations of the fixed-effect and random-effect models (Eqs. 2 and 4).

The findings of the fixed effects panel data regression are shown in Table 3, which identify a few variables as significant drivers of RE investment. The R square value of 0.813 suggests a satisfactory fit for the fixed effects model, according to the panel regression findings for the fixed effects model. As a result, all exogenous variables combined could account for about 81% of the variation in REC. Even though all coefficients are nonzero, an F-statistic probability of 0.000 suggests that the overall panel regressions are significant ($F<0.05$). A positive link between REC and energy usage and R&D was discovered using panel data fixed effects regression. In other words, a 1% increase in energy consumption and R&D spending results in a 0.007% rise in REC growth. This finding is supported by recent research by Khezri et al. (2021) and Wu et al. (2020). The findings suggest that R&D spending has a favorable impact on RE sources, such as solar, wind, bio-energy, and geothermal.

On the other hand, GDP, electricity power consumption, RE policies, and CO_2 emissions are inversely correlated to REC. The negative relationship between CO_2 emissions and REC was an astonishing outcome. However, recent studies by Ponce and Khan (2021) find that RE and energy efficiency is negatively related to CO_2 emissions, and Gyamfi et al. (2021c) found a negative relationship between RE and CO_2 emissions for Mediterranean area countries. Similarly, Zaidi et al. (2018) show that REC has an insignificant effect on CO_2 emissions in Pakistan, and Gyamfi et al. (2021b) shows that there is no significant relationship between RE and CO_2 emissions for E7 countries. Recent studies by Gyamfi et al. (2021a), on the other hand, found that a 1% increase in RE consumption in E7 countries improved the environmental quality by 0.588%.

Another conclusion drawn from the study is that there is no statistically significant link between REC and income (economic growth) or renewable policy. The findings obtained from the analysis are also supported by the literature. According to Hughes (2010), FITs fail in the UK because they prevent local promotion of RE capacity. Likewise, Delmas et al. (2007) established that the quota (RPS) policy system had no effect on RE production.

These findings mean that the current RE policies are insufficient to promote investment in RE. Furthermore, the world's three largest economies (the USA, China, and India) declared net-zero carbon goals, and the UK hosted the UN Climate Change Conference (UNCCC) of the Parties (COP-26) in October–November 2021, which resulted in new important agreements for UNFCCC implementation. However, it has been accepted that the steps planned will not prevent irreversible climate change. Governments should work harder in partnership with businesses, science, and civil society. Although, this result shows that countries should devote more resources (policy and R&D) to RE investments in order to attain net-zero ambitions (UNCC, 2022).

The R-square value was 0.69, and the Prob. (F-statistic) was 0.129, according to the random effects model result in Table 3. While there is a positive correlation between REC with energy consumption and R&D; there is a negative relationship between GDP, electric energy consumption, RE policies, and CO_2 emissions with REC. These findings provide insights for reconsidering RE and CO_2 emissions policy formulations for adopting cleaner and greener technologies (Gyamfi et al. 2020a).

In the regression model that looked at REC in OECD and BRICS nations between 2000 and 2020, the Hausman test was used for exogenous variables. Table 4 shows the results of the Hausman test.

As seen in Table 4, H0 is rejected because the random effects correlated Hausman test result is $p>0.05$, the fixed effect model is more appropriate to estimate the net effect of exogenous variables on REC, and the alternative H1 hypothesis is accepted. Here, the fixed effect model's R^2 score indicates it is suitable for the GMM model. Table 5 shows the findings of the GMM model.

According to the panel regression results for the GMM model, all variables are statistically significant ($p<0.05$), indicating that it is appropriate. The findings are consistent with the fixed effects model's results: there are positive correlations between RE capacity, GDP per capita, RE policies, and R&D. RE policies and R&D spending cause REC to expand by 0.06%, 0.02%, and 0.02%, respectively, with a 1% growth in GDP per capita. Recent research has discovered similar results (Gershon and Emekalam, 2021; Tudor and Sova, 2021). According to Sadorsky (2009), for G7 countries, a 1% increase in GDP per capita boosts RE consumption by 3.5%. Recent research has discovered similar results (Gershon and Emekalam, 2021; Tudor and Sova, 2021). According to Sadorsky (2009), for G7 countries, a 1% increase in GDP per capita boosts RE consumption by 3.5%. Similarly, Baye et al. (2021) find that a 1% rise in real GDP per capita results in a 0.32% increase in REC in African countries. Omri and Nguyen (2014) find that economic development is the key driver for REC growth using a two-stage GMM panel estimate regression technique for 64 nations. In high-income, middle-income, and low-income nations, a 1% rise in GDP per capita improves the REC by 0.199%, 0.169%, and 0.149%, respectively.

Conversely, there are negative correlations between REC, energy use, electricity consumption, and CO_2 emissions.

REC drops by 0.03%, 0.02%, and 0.23%, respectively, when energy consumption, electricity consumption, and CO_2 emissions consumption all rise by 1%. These findings are in line with some previous research. For example, Baye et al. (2021) show that CO_2 emissions have a negative impact on REC per capita in sub-Saharan African countries, and they attribute this to energy inefficiency and a lack of environmental awareness.

Conclusion and policy implications

The impact of many variables on RE investment is demonstrated in this paper. This research aims to develop a conceptual framework for quantitatively assessing RE investment from the perspective of investors, and then a quantitative test provides useful insight into the investor's role in promoting the growth of RE technology. This study provides a systematic and quantitative method for comparing the implications of variables in OECD and BRICS countries, allowing for easy comparisons.

The paper discovered a statistically significant association between RE and energy consumption, electric power consumption, R&D, and CO_2 emissions according to the fixed effect model results. However, although energy consumption and R&D and REC have a statistically positive link, electricity consumption, RE policies, and CO_2 emissions have a statistically negative relationship. For the OECD and BRICS countries, the GMM approach revealed a statistically significant link between all explanatory variables and RE capacity. It was concluded that while RE policies, R&D, and economic growth promote RE investments, CO_2 emissions, energy and electricity consumption negatively affect RE investments. Because of rising energy and electricity consumption, OECD and BRICS countries choose fossil-based energy sources from RE sources.

Considering the findings, it is vital to design a national policy on economic growth, research and development, and RE policies that are effective in RE investments. It illustrates that in order to grow RE investments, both the OECD and the BRICS countries must focus more on their policies. Increasing the share of R&D spending in the RE sector, in particular, will stimulate current technology while simultaneously reducing CO_2 emissions. In addition, the OECD and the BRICS countries should collaborate to develop energy-efficient and efficient projects, as well as to support environmental and sustainable activities. As a result, it has the potential to attract green investments from both the public and private sectors. Governments should devote greater resources to increasing public understanding of eco-friendly topics. According to the findings, the OECD and BRICS countries should establish policies to encourage more RE investment in order to meet their net zero carbon commitments, and that increased country cohesion is advocated. Sustainable development, which is founded on the principles of ensuring energy security, will enable green development at the national level, safeguarding the environment from the detrimental effects of fossil fuels, and combating climate change. The study's findings indicate that harmonization of national and an international energy standard is crucial.

Another significant policy recommendation from the study is that consumers should be able to access RE because of technological constraints. Although the Russian Federation of the BRICS countries has significant RE potential, the volume of commercial RE consumption other than hydro, such as wind and solar, is insufficient to attract the necessary investment. As a result, authorities must foster the right investment climate to encourage the commercialization of RE. Furthermore, RE strategies should emphasize education to increase RE consumption. The training exercises should emphasize RE's potential contribution to sustainable development and a clean environment, among other energy sources. Gyamfi et al. (2020b) emphasized that policymakers in China, Turkey, Russia, India, Indonesia, Brazil, and Mexico must invest heavily in expanding both clean energy generation (RE) and hydroelectric power, which produces less CO_2 emissions in the long run.

The paper only covers OECD and BRICS countries. Another point to consider is that the study is based on a few variables that have been classified. Correspondingly, this paper does not address the financing challenges in RE investments and RE projects. The paper does not discuss in depth the relationship between the financing of RE and its investment. Finally, other factors that are effective in RE investment are not included in the analysis, and the analysis is limited to the countries of the two regions. These issues can/will be addressed in future research as well. Besides these, Ahmad et al. (2021) and Isik et al. (2020) emphasized that the behaviors of individuals are reshaped during pandemic times such as COVID-19, and therefore, more empirical studies on the change in the behavior of RE investors may be needed in this time period.

Appendix

Table 6 Variable summary statistics

	REC	CO_2	EC	EPC	GDP	R&D	REP
Observations	798	798	798	798	798	798	798
Mean	3.900375	0.884710	1.420833	3.802345	4.498922	0.067673	−0.782985
Median	3.995414	0.919109	1.433140	3.828870	4.577434	0.261611	−1.000000
Maximum	5.951570	1.421597	1.749597	4.813041	5.060279	1.246940	−0.003795
Minimum	0.845098	−0.034657	0.975390	1.397940	3.411383	−1.524778	−2.187087
Std. Dev	0.867208	0.238532	0.132296	0.333615	0.288492	0.582450	0.353748
Skewness	−0.772619	−0.912992	−0.118781	−0.686563	−1.242475	−0.838361	0.316284
Kurtosis	3.907878	4.874968	3.243383	7.701421	4.818040	2.594141	3.235723
Jarque–Bera	106.7991	227.7534	3.846062	797.6287	315.2182	98.95599	15.15230
Probability	0.000000	0.000000	0.146163	0.000000	0.000000	0.000000	0.000513
Sum	3112.500	705.9985	1133.825	3034.271	3590.140	54.00327	−624.8222
Sum Sq. Dev	599.3832	45.34727	13.94937	88.70527	66.33256	270.3806	99.73466

Table 7 Variable correlation

	REC	GDP	EC	EPC	REP	R&D	CO_2
REC	1.00	−0.11	0.31	−0.03	0.05	−0.20	−0.29
GDP	−0.11	1.00	−0.37	0.59	0.17	0.48	0.57
EC	0.31	−0.37	1.00	0.03	−0.17	−0.29	−0.21
EPC	−0.03	0.59	0.03	1.00	−0.01	0.36	0.62
REP	0.05	0.17	−0.17	−0.01	1.00	0.18	0.02
R&D	−0.20	0.48	−0.29	0.36	0.18	1.00	0.42
CO_2	−0.29	0.57	−0.21	0.62	0.02	0.42	1.00

The table shows the correlation coefficient for all variables in the current paper and the variables are summarized in Table 6

Table 8 Summary of recent literatures

Author (s)	Location	Period	Method	Results
Oosthuizen et al. (2022)	OECD Countries	1997–2015	Panel data analysis	The results show that the share of RE in the energy mix has a positive and statistically significant effect on retail electricity prices
Mngumi et al. (2022)	BRICS Countries	2005–2019	Panel quantile regression	As a result, increases in the use of RE and progress in the green finance development index have contributed to the reduction of CO_2 emissions from BRICS countries. CO_2 emissions have slowed the growth of RE use, slowed the flow of investment in green projects, and ultimately hindered the development of green finance
Hashmi et al. (2022)	Global Index	1970–2015	ARDL approach	The findings show that a 1% increase in geopolitical risk in the short term inhibits emissions by 3.50% globally. In the long run, a 1% increase in geopolitical risk increases emissions by 13.24%
Isik et al. (2022)	50 US States	1990–2017	Armey curve model	The maximum level of spending for the 7 US states has been calculated as approximately 15% of their GDP and has an impact on environmental degradation
Ongan et al. (2022)	NAFTA Countries	1971–2016	Armey curve model	If the composite model were meaningful in the study, it could make it possible to quantify the maximum level of real GDP per capita that would minimize or maximize CO_2 emission levels for the USA
Belaïd et al. (2021)	MENA Region	1984–2014	Panel quantile regression	The findings reveal that the impact of political stability is clearly heterogeneous and the importance of political stability to stimulate investment in the RE sector. The findings also show that financial development has a positive impact on RE generation
Marra and Colantonio (2021)	12 EU Member Countries	1990–2015	Panel vector autoregressive approach	The results show that the level of carbon dioxide emission (negative) dominates in its impact on RE consumption. Increasing energy needs push traditional sources towards complementarity with RE consumption, which means a positive lobbying effect. Public awareness is not enough to facilitate the transition to RE consumption
Shahzad et al. (2021)	29 developed countries	1994–2018	Panel cointegration and panel regression analysis	The findings show that environmental regulations and income level support renewable electricity generation. The results also indicate that bureaucratic attributes such as decision-making and trade openness tend to reduce RE generation
Rehman et al. (2021a)	Pakistan	1975–2017	Nonlinear-ARDL approach	The study results revealed that the negative shocks of RE consumption clearly increase CO_2 emissions in short-term dynamics. Conversely, constructive shocks of RE consumption show a negative correlation with CO_2 emissions

Table 8 (continued)

Author (s)	Location	Period	Method	Results
Rehman et al. (2021b)	Pakistan	1985–2017	ARDL approach	The results show that trade and RE are constructively linked to GDP growth in the long run
Isik et al. (2021a)	USA, Canada, and Mexico	1961–2016	Panel unit root test	The findings show that there is convergence of ecological footprint in the second regime, which represents %48.08 of the sample, and difference in the first
Isik et al. (2021b)	8 OECD Countries	1962–2015	Regression	Empirical findings indicate that the undecomposed model with undecomposed per capita GDP series supports the EKC hypothesis for 4 out of 8 countries
Dogru et al. (2020)	OECD Countries	1995–2014	Panel data analysis	The findings showed that tourism development has negative and significant effects on CO_2 emissions in Canada, Czechia, and Turkey, while tourism development has positive and significant effects on CO_2 emissions in Italy, Luxembourg, and the Slovak Republic
Egli, (2020)	Germany, Italy, and UK	2009–2017	Network analysis	Risks of investment in RE technologies are constraint, policy, price, resource, and technology. It is revealed that risk premiums and investment risk for solar photovoltaics and onshore wind technologies have decreased in all three countries
Melnyk et al. (2020)	36 OECD Countries	2001–2015	Panel data analysis	The results show that an increase of US$10,000 in GDP in national economies led to an average decrease of 3.9% in renewable electricity generation over the period 2001–2015
Isik et al. (2019a)	10 US states	1980–2015	Panel estimation method	The negative effects of fossil energy consumption in Texas on CO_2 emission levels are not statistically detectable, even though this state is the leading oil producing state. In addition, the positive effect of renewable energy consumption in Florida, which is officially known as the "Sunshine State," is quite low compared to other states
Isik et al. (2019a)	50 US states	1980–2015	CD (cross-sectional) test	The expected negative environmental impacts (CO_2 emissions) of fossil energy consumption have been strongly identified in all states except Texas. However, the expected positive effects of renewable energy consumption on CO_2 emissions were detected in only 13 states
Moutinho et al. (2018)	23 countries in the world	1985–2011	LMDI decomposition method	The findings show that the efficiency of renewable resources and the financial development impact on renewable electricity generation per GDP are the main culprits for the total and negative changes in CO_2 emissions over the last decade

Table 8 (continued)

Author (s)	Location	Period	Method	Results
Inglesi-Lotz and Dogan (2018)	Sub-Saharan Africa	1980–2011	Panel data analysis	According to the results, increases in RE consumption reduce pollution. In addition, a unidirectional causality running from emissions, income, trade, and non-renewable energies to renewable energies was also found
Isik et al. (2018)	USA, France, Spain, China, Italy, Turkey, and Germany	1995–2012	Panel Granger causality	According to the results, while there are RE-based growth theories in Spain, there is confidence in growth-based RE theories in China, Turkey, and Germany
Weideman et al. (2017)	South Africa	1990–2010	Structural break test method	The findings reveal that although the South African government made significant RE commitments in the 1990–2010 period, these have not yet led to structural breaks in the RE market
Nakumuryango and Inglesi-Lotz, (2016)	South Africa and OECD Countries	1990–2010	Comparative analysis	The findings show that although South Africa is in the best position economically, it is not the best performing country among African countries for RE. Also, when South Africa is compared with OECD countries, it shows that South Africa has a long way to go in order to achieve a sustainable environment
Sisodia et al. (2016)	EU Countries	1995–2011	Panel Data Analysis	The results show the importance of reliable regulatory plans to ensure that regulation does not have a significant negative impact on investment, and also the need to further expand the model to include support plans as key drivers for investment
Chang et al. (2015)	G7 Countries	1990–2011	Panel Granger causality	The empirical results support the existence of a bidirectional causal relationship between economic growth and RE. However, when looking at the results for each country separately, the neutrality hypothesis is confirmed for Canada, Italy, and the USA

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Declarations

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