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Testing role of green financing on climate change mitigation: Evidences from G7 and E7 countries

Xueying Wu¹ · Muhammad Sadiq² · Fengsheng Chien^{3,4} · Quang-Thanh Ngo⁵  · Anh-Tuan Nguyen^{6,7} · The-Truyen Trinh⁸

Abstract

The study estimates the long-run dynamics of a cleaner environment in promoting the gross domestic product of E7 and G7 countries. The recent study intends to estimate the climate change mitigation factor for a cleaner environment with the GDP of E7 countries and G7 countries from 2010 to 2018. For long-run estimation, second-generation panel data techniques including augmented Dickey-Fuller (ADF), Phillip-Peron technique and fully modified ordinary least square (FMOLS) techniques are applied to draw the long-run inference. The results of the study are robust with VECM technique. The outcomes of the study revealed that climate change mitigation indicators significantly affect the GDP of G7 countries than that of E7 countries. The GDP of both E7 and G7 countries is found depleting due to less clean environment. However, green financing techniques helps to clean the environment and reinforce the confidence of policymakers on the elevation of green economic growth in G7 and E7 countries. Furthermore, study results shown that a 1% rise in green financing index improves the environmental quality by 0.375% in G7 countries, while it purifies 0.3920% environment in E7 countries. There is a need to reduce environmental pollution, shift energy generation sources towards alternative, innovative and green sources. The study also provides different policy implications for the stakeholders guiding to actively promote financial hedging for green financing. So that climate change and environmental pollution reduction could be achieved effectively. The novelty of the study lies in study framework.

Keywords Cleaner environment · Green financing · Climate change · E7 countries · G7 countries

Introduction

The cleaner environment notion is still emerging, and it is much valuable in current policies and agendas. The rising trends of

global warming have greatly interested the policymakers to clean the environment using climate change mitigation strategies, and it seems to be a part of a broad consensus. However, social, geographic and regional impacts of climate change take on

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another dimension particularly following the mission to clean the environment of densely populated regions and projects (Alemzero et al. 2020a). All these initiatives to clean the environment through climate change mitigation are inclined towards energy development and consumption sources, leading to a significant improvement in energy sectors in different regions and projects (Li et al. 2021b). E7 and G7 regions are one of the important projects expected to face multiple environmental and climate change orientated threats. Thus, it is prerequisite to clean the environment using climate change mitigation strategies for effectiveness and smooth economic growth of E7 and G7 region (Li et al. 2021a, 2021b, 2021c). However, there is a need for safe and less polluted climate but also the need to develop and implement green financing strategies in different forms; that is to say, “clean” without harming the climate and especially without affecting the economic growth of E7 and G7 regions (Iqbal et al. 2021a). Hence, endorsing the importance of BRI and E7 and G7 regions, recent study intends to estimate the antecedents of cleaner environment by using green financing techniques on long-run basis and provide the way forwards for policymakers to mitigate the climate change (Anh Tu et al. 2021; Alemzero et al. 2021).

Climate change and global warming causes greenhouse pollution that is regarded as the greatest challenge of the twenty-first century (Iqbal et al. 2020). In 2015, 196 countries joined the Climate Change Agreement in Paris to hold the annual temperature increase well below 2 °C to mitigate the extreme effects of global warming (Asbahi et al. 2019). The performance of the Paris Agreement and other associated environmental emission policies largely depends on the administrative efficiency of the government (Yumei et al. 2021; Iqbal et al. 2021a). Institutions establish and regulate carbon reduction environmental programs. These structures come in several directions, such as politics, government and the society, and are affected by multiple factors (Anh Tu et al. 2021; Chien et al. 2021d; Chien et al. 2021a). The destruction of the environment and climate change are growing quickly as the demand for innovative and viable solutions is rising. The green economy is one of the most effective strategies for resolving these issues and promoting recycling of economic capital, economic development and environmental protection (Chien et al. 2021b; Chien et al. 2021c; Chien et al. 2021e). The social welfare mechanism thus preserving environmental destruction to a minimum may be considered a green economy (Tvaronavičienė 2021). The important impact of the green economy on sustainable growth is one of the issues highlighted at the United Nations Conference on Rio+20 (Chien et al. 2020; Chien et al. 2021c). The main variables involved in the development of a green economy must be given equal priority. This study focuses on public procurement as one of the key influences of the green economy (Richards et al. 2021). A basic alteration of public expenditure, given the previous literature, would appear to have a major effect on economic and environmental depletion. The specific nature of the connection between public expenditure and green economic development has not yet been analysed in

depth (Li et al. 2021c; Sadiq et al. 2020). A comprehensive analysis of fiscal expenditure will help define its connection to green economic development (Anser et al. 2018; Anser 2019; Anser et al. 2020).

The essence of this partnership can be identified by environmental studies like (Abhimanyu Kumar 2019). For example, a sequence of effects called the ‘size impact’ reflects how economic activity rises with a rise in government spending. However, this mechanism causes numerous environmental threats, with green economic development gradually dropping (Asif et al. 2020; Sarker et al. 2020; Iram et al. 2020; Tehreem et al. 2020). In the other side, a major transition in the ‘composition effect’ of capital-based industry into human capital-based industries with a rise in public education expenditures may be observed. As a consequence of the compositional impact, a new model of economic growth is viable as pollution is reduced (Ossebaard and Lachman 2021). Nations can be motivated to use more cleaner technology and renewable energy with a large allocation of science and innovation capital (Zhao et al. 2020b). The usage of these innovations will ensure improved resource productivity and healthier production (Marvin Herndon and Alberto Pérez Bartolomé 2018). A minimum pollution/output ratio may be observed utilizing a method known as the ‘scientific effect’. An approximate \$2 trillion is needed to help the planet recover sustainably from COVID-19’s global retrogression. This money will be used to invest in green schemes such as renewables to complete the COVID-19, 2021–2023 period (Yousaf et al. 2020; Tehreem et al. 2020; Wasif Rasheed and Anser 2017; Xu et al. 2020).

Only these structural investments, such as private investments, renewable bonds, and committed financing, will ensure a complete and long-term recovery (Agrawala et al. 2020.). The G-7 and E-7 countries will comfortably achieve a W-shaped or a V-shaped green recovery outlook. COVID-19 has resulted in a lower CO₂ level (Kumar and Ayedee 2021). However, it has had a negative impact on global development due to economic challenges and human misery. The G7 and E7 countries help all member countries to build and promote broad markets whilst still promoting mutual understanding. The activities of emerging countries of theoretically creating considerable dependence on energy supplies, while growing their manufacturing productivity by an advanced development mechanism, indicate a relatively secure economic condition. Another major issue addressed by the BRI initiative is global warming, which can be addressed by strong collaboration among member countries. In developing countries, there is a lot of study on different environmental concerns. In the developed countries, there is a lack of study. In terms of industrial and non-renewable resources, the economy has seen substantial expansion. In general, dependence on the manufacturing sector and non-renewable energy services has boosted economic development by a fraction, although the prospect of green economic growth has risen

dramatically at the same time due to significant environmental deterioration (Letcher 2018).

This study's valuable insights can contribute to the literature significantly while explaining how the green economy is affected by public spending. However, studies have not been able to identify the specifics of how government spending affects market mechanisms. A positive relationship between fiscal spending and green economic growth can be seen in this study (Khan et al. 2019; Isaksen and Trippel 2017). This study assesses how G7 and E7 countries are stimulating green finance and carrying out strategies to reduce climate change. Green finance can be replaced by renewable energy consumption while making use of the FOMS and VECM approach on the G7 and E7 countries. Few studies have analysed the G7 and E7 countries (Yildirim et al. 2014; No and Padhan 2018; Erdoğan et al. 2020; Sinha et al. 2020) while using the econometric method. This study's significant difference lies in using the FOMS and VECM approaches to assess long-run dynamics of cleaner environment with economic growth indicators, in the context of E7 and G7 countries.

The rest of the paper is organized as follows: the 'Literature review and background' section represents how G7 and E7 countries are affected by green and climate change mitigation. The 'Data and methodology' section represents the methodology used in the study. The 'Results and discussion' section states the result and discussion for the study, while the 'Conclusion and policy implications' section states the conclusion and policy implications.

Literature review and background

Despite reductions in fossil fuel consumption and CO₂ emissions, the electricity industry remains the world's most significant and largest producer of these emissions (Iqbal et al. 2021b). Human-induced and CO₂ emissions from the electricity industry make up two-thirds of both human-driven and CO₂-based emissions, which have increased sharply over the century. Many nations plan to reduce their dependence on fossil fuels and get down to 75% of total global resources by that year. As a consequence, ambitious energy policy is vital to solving the climate change problem (Liu et al. 2020; Lin et al. 2020; Jun et al. 2020). While few studies have concentrated on the connection between clean energy consumption, CO₂ emissions and economic growth, several previous studies have highlighted the correlation between nuclear energy consumption, renewable energy consumption, CO₂ emissions and economic growth, which may help us better understand the relationship between clean energy consumption and other variables (Iqbal et al. 2021c).

Development and enhancement of agricultural production capacity, together with the usage of renewable energy, are vital for developed countries to achieve sustainable growth. Between 2016 and 2050, according to a PWC survey (2017), the global

economy is predicted to expand at a real annual pace of about 2.5%. The E7 countries—China, India, Brazil, Russia, Mexico, Indonesia and Turkey—are expected to develop at an annual average pace of about 3.5% over the next 34 years, opposed to just about 1.6% for the advanced G7 nations. According to the Bloomberg New Energy Finance Report (2016), in terms of overall new clean energy spending, emerging countries overtook industrialized countries for the first time in 2015.

More so, in 2015, green energy expenditure grew by 16% in China, India and Brazil, the top three E7 nations, to \$120.2 billion, while investment in 'other emerging' countries increased by 30% to \$36.1 billion. The presence of a significant renewable energy resource is at the core of the E7 countries' challenges in achieving balanced agricultural growth and increasing domestic demand. The option to encourage sustainable energy sources would not only contribute to more modernization of the energy market but would also help various countries' economic growth and sustainability goals. The influence of NER and RER sources on greenhouse gas emissions is also demonstrated by geographic variability in the literature (Wasif Rasheed and Anser 2017; Xu et al. 2020; Ahmad et al. 2020). However, scant research has been done on the effect of environmental protection strategies on greenhouse gas emissions (Li et al. 2021d). The position of environmental protection policies, the usage of renewable and non-renewable energy supplies and per capita GDP growth on greenhouse gas emissions in emerging Asian economies is highlighted in this report, which adds to the current literature (Anh Tu et al. 2021).

Source: author's findings

As seen in the discussion above, there is a need to extend the body of knowledge and extend the research on the relationship between energy and development all agree with the literature review in Table 1. However, there is a scarcity of evidence on the impact of energy demand on economic development in emerging Asian economies in general. There is also no proper conclusion or findings in this data. As a result, there is a pressing need to put the energy growth nexus discussions to rest (Mohsin et al. 2021; Tang et al. 2018). Furthermore, there is yet to be released a report that explores the impact of renewables on economic development incorporating both renewable and non-renewable energies. As a consequence, this research is important in bolstering the third strand of literature, which seeks to fill this void in the literature for emerging Asian economies.

Data and methodology

Study measures and data

To estimate the long-run modelling of study constructs, we used growth functions. The unit of measurements used for

Table 1 Renewable and non-renewable energies and economic growth

Time duration	Region	Method	Findings
1990–2014	15 renewable consuming	Granger causality test	Growth
1980–2015	ASEAN-5	Causality	Neutrality
1980–2010	Brazil	Vector error correction model	Growth
1980–2012	Sub-Saharan	Pairwise heterogeneous causality	Neutrality
1980–2012	16 emerging economies	Bootstrap causality	Feedback growth and neutrality
1980–2012	BRICS	Panel error correction model	Conversation
1971–2012	India	Vector error correction model	Feedback
1980–2010	34 OECD	Panel cointegration	Growth
1990–2007	16 emerging countries	Panel error correction model	Feedback and growth
1949–2006	USA	Toda-Yamamoto causality method	Feedback, growth and neutrality
1997–2015	Pakistan	VECM	Growth and feedback

levels of carbon dioxide emission is in kilotons (kt) serving as a proxy measure of cleaner environment, GDP in US dollars (Vasylieva and Bilan 2019), the population in % and technical operation grants in US dollars, whereas the foreign direct investment (FDI) is measured in USD, human development index in %, renewable consumption as a proxy for green finance in kilotons (kt), inflation in %, GDP in USD 2017 purchasing power parity (PPP), domestic investment private participation in the energy sector in USD while the local credit in dollars, specific for the private sector. The data for G7 and E7 countries was taken from different databases, such as databank.worldbank.org, fred.stlouisfed.org and data.worldbank.org, for the years of 2010–2018 to execute empirical analysis. In E7 countries, China, India, Brazil, Mexico, Russia, Indonesia and Turkey were taken, while the USA, UK, Germany, Japan, France, Italy and Canada were taken in G7 countries. In total, 14 countries were taken which are major countries facing issues in terms of environmental pollution and reduction in economic growth. Subsequently, this is to assess the long-run dynamics of cleaner environment on economic indicators. The cleaner environment is also assessed by using the green performance index data of E7 countries and G7 countries. Notably, the empirical statistics revealed that G7 countries are more attentive to clean the environment for climate change mitigation, concerned to gain environmental sustainability and this matters them most than E7 countries.

Econometric modelling

In this study, we examine the impact of climate change on macroeconomic indicators of G7 and E7 regions. To acquire the study objectives, we consider two models (Y, growth function; and CE, environmental function), which are specified as follows:

$$Y_{it} = f(X_{it}; Pre_{it}; Post_{it}) \quad (1)$$

In Eq. (1), Y_{it} is the dependent variable of the study, X_{it} is the composite function including GDP, FDI, population, R&D expenditures, CO₂ emission, human development index score, inflation, grants, DCP and investment in power plants. Pre_{it} is pre-test exposure of the countries to the climate change and green financing, while $Post_{it}$ is the examined function showing the exposure of the countries to the climate change and green financing (e.g. undertreated). The panel form of Eq. (1) is developed into Eq. (2):

$$\ln Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Pre_{it} + \beta_3 Post_{it} + e_{it} \quad (2)$$

where i designates countries; t represents the period; α_0 represents the fixed country effect; and ε is the white noise. \ln is the natural logarithms of all variables. Moreover, the logarithmic form of Eq. (3) is developed as

$$\ln Y_{it} = \beta_0 + \beta_1 \ln(X)_{it} + \beta_2 \ln(Pre)_{it} + \beta_3 \ln(Post)_{it} + e_{it} \quad (3)$$

where the country, t is the period, and e_{it} is the error term. The parameters, such as, β_1 , β_2 and β_3 , represent the long-run elasticity estimates of Y , X , pre-test exposure and post-test exposure of the countries, in G7 and E7 regions, respectively (Li et al. 2020; Li et al. 2021a; Yu 2021).

Strategy for econometric estimation

A panel stationary test is applied to test/to assess the order of variable integration. For this, augmented Dickey-Fuller (ADF) technique (1979) and Phillips and Perron (1988)

are used to determine unit root among variables. The study used the hybrid strategy for the estimation of study constructs to infer the findings, in two ways (Mohsin et al. 2018a; Mohsin et al. 2018b; Ikram et al. 2019). First, the study applied FMOLS approach to show the evidences on climate change mitigation and economic growth. This approach shows construct-wise and country-wise differences interpreting the pre- and post-consequences of climate change on the economic performance of G7 and E7 regions. Secondly, we used panel cointegration and panel long-run elasticity's functions to strengthen the findings of FMOLS approach. This approach supported the operationalization part of the study findings by proposing the estimated residuals to give the findings in terms of long-run (Adedoyin et al. 2020). However, hypothesized form of Eq. (4) for long-run regression technique is as follows:

$$Y_{it} = \lambda_1 + \vartheta_1 t + \sum_{j=1}^n \lambda_j X_{j,it} + e_{it} \quad t = 1 \dots T; \quad i = 1 \dots N \quad (4)$$

Extending to it, fully modified OLS method is used to estimate the nature of heterogeneity among the variables to measure the intensity of relationship. According to Pedroni (2000), this method allows to operationalize and rectify the expounding variable's endogeneity with different vibrant data sheets. The use of FMOLS presupposes that the variables have a cointegration connection. As a result, we begin with unit root tests on each of the data set (Sun et al. 2020d; Baloch et al. 2020).

Robustness: vector error correction modelling (VECM)

The cointegration of variable estimation supported to develop the casualty among variables. For this and long-run inference of results, we applied VECM methods by using two-step process.

Table 2 shows the probit and logit figures of E7 and G7's economic performance. Eaccess and Enimp are unlikely to affect the energy performance of the countries studied in this report. The EE is likely to be influenced by FDI, as predicted. This is shown by an increase in Chinese investments in Africa and SSA. The GDP would have an effect on the energy production of E7 and G7 nations, as well as fossil fuels, taxes, QPI, LPI and ENEEMIS. The coefficients of the probit model demonstrate this. As seen in Table 2, the countries under review with energy access have a probable effect on energy efficiency of [39.5646%]. Energy imports, on the other side, have little effect on the countries under review, with a negative mean [- 45.13979], showing that energy imports have little effect on EE in the E7 and G7 nations. The F-

statistics in the VECM may indicate short-run causality, whereas the error correction word ECT (1) may indicate long-run causality.

$$\begin{bmatrix} \Delta Clim \\ \Delta Eco \\ \Delta Soc \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix} + \sum_{m=1}^n \begin{bmatrix} \delta_{11} & \delta_{12} & \delta_{13} \\ \delta_{21} & \delta_{22} & \delta_{23} \\ \delta_{31} & \delta_{32} & \delta_{33} \end{bmatrix} \times \begin{bmatrix} \Delta LnClim_{it-m} \\ \Delta LnEco_{it-m} \\ \Delta LnSoc_{it-m} \end{bmatrix} + \begin{bmatrix} \vartheta_1 \\ \vartheta_2 \\ \vartheta_3 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{bmatrix} \quad (5)$$

In Eq. (5), three main dimensions were taken, such as environmental, social and economic, to assess the cleaner environment, climate change and economic growth prospects in BRI project and G7 and E7 regions. The vector error (VECM) form of study model is written and sub-divided into proxies as follows, where Δ , δ_{it} , γ_{it} , i , t and μ_{it} represent the first difference operator, the constant term, the parameters, the period and the error term, respectively. Using above econometric models, we used long-run growth prospecting econometric function (see Eqs. 5 and 6) of G7 and E7 regions. For growth regression, an index of economic indicators was developed including GDP, FDI, INF, R&D and IPP. Index of social indicators was also developed including GRT, HDI and PoP, while environmental factors were assessed using CO₂ emission index, as a measure of climate change mitigation. Our findings are consistent with Sun et al. (2020d) and Baloch et al. (2020). Various similar techniques have been used in multiple applications (Zhao et al. 2020a; He et al. 2021; Zhang et al. 2020a; Zhang et al. 2020b).

Results and discussion

Empirical analysis

The results indicate that decreased fossil fuel usage and increased renewable energy consumption caused development in the E7 and G7 regions. This point is backed up by citing Indonesia's goal of producing 5% of its electricity from geothermal; 5% from wind, biomass, hydro and solar; and 5% from biofuel by 2025. In order to improve and achieve a low-carbon economy, Indonesia initiated the Low Carbon Development Initiative (LCDI). This aim also promotes the creation of a policy suite and modular transformation programs that can be used in various economic sectors. These revolutionary processes could result in economic growth of 5.6% by 2020 and 6.0% by 2045. In the best-case scenario, 15.3 million good green workers will be introduced by 2045, resulting in a \$5.4 trillion GDP boost. Poverty is projected to fall from 9.8% of the population in 2018 to 4.2% in 2019. About the same way, better air quality is projected to save 40,000 lives (Zeng et al. 2017). During the period 2005–

Table 2 Probit and Logit estimates for economic efficiency

Countries	Constructs	Eaccess	Enimp	FDI	GDP	Foss	Taxes	QPI	LPI	Eneemis
E7	Probit	− 0.016	− 0.043	0.059	0.033	0.098	0.003	0.073	0	0.001
	Logit	− 0.027	− 0.086	0.114	0.054	0.196	0.002	0.129	0	0.001
G7	Probit	− 0.028	− 0.056	0.71	0.088	0.097	0.000	0.029	0	0.000
	Logit	− 0.017	− 0.099	0.25	0.041	0.234	0.059	0.011	0	0.000

2015, the Philippines is expected to raise its renewable energy by 100%. In the last six years, the Philippines' economy has expanded at a steady pace of 6.6%. By 2030, it intends to build 2.35 GW of wind power. However, the theoretical capacity is 76 GW (Baloch et al. 2020). With steady GDP growth of 6% over the last decade, Vietnam can be called another booming economy. Its clean energy goals are 5% in 2020 and 11% in 2050, respectively (Ma et al. 2019). The nation currently has 228 MW of installed wind power and expects to build 800 MW by the end of 2020. The G7 and E7 countries have a large energy intensity ratio, which should be ample incentive for them to engage in energy production and conservation (Sun et al. 2020e; Sun et al. 2020c; Sun et al. 2020d).

The ADF and PP unit root results are tabulated in Table 3, presenting that study results are stationary at level and some of the measures, such as CO₂ emission, REC and per capita GDP are stationary at level. The results indicated that null hypothesis is accepted and the variables are stationary at first difference, highlighting that variables are cointegrated in a singular order. Extending to it, cointegration test is applied to build more econometric clarity in study results.

We used the FMOLS methodology to calculate the long-term association between variables. It validates the growth theory, which maintains that economic growth is generated by energy usage. As an economy grows, the energy use is often dependent on labour and resources, as well as other factors such as population, place and technology (Alemzero et al. 2020a). Are you a masochist? These findings indicate that green energy use has a favourable effect on 1% of the national economy—that a rise in renewable energy demand of 22% would result in 1% in the growth of the overall economy. According to the G7 formula, a 1% GDP percentage point raises the carbon emissions of 1% of a country's population by 4.55%. There is an ever-increasing volume of data supporting the argument that development in the gross domestic product (GDP) and population leads in a rise in carbon dioxide emissions, according to several analyses (Solaymani 2019). Even countries with a high GDP, such as the USA, China, Japan and Germany are still very populated (Chandio et al. 2020; Alemzero et al. 2020b; Sun et al. 2020c; Alemzero et al. 2020a).

An insignificant 2% risk that energy-related pollution would affect the atmosphere the other change in the variable could result in a small change in the percentage Energy efficiency decreases by about eight percent as the percentage of energy access varies. Although between 4 and 6% of the participants of the G7 have a strong impact on their gross domestic product (GDP), foreign direct investment (FDI) has a high mean influence on overall direct investment (QPI). Table 6 predicts that the respective mean and standard deviation for the logit and probit models lie between 0 and 1 The formula would not limit the range of probabilities to 0–1 for the Logit model, which means they will take on every possible logit value. An equivalent or even higher mean value for Ei, an equal mean for G7 and E7 countries with respect to energy production. As said above, the sensitivity and specificity models were accurate in their predictions (Sun et al. 2020b; Sun et al. 2020a). See Figure 1 where the model has a sensitivity of 89.33 and a reported value of 92.42, but a negative accuracy of 58.93. The findings of this analysis indicate was considered to be right to be at 84.21% Although 84% of the model has been estimated to be right, the majority of the assumptions are in error. It is shown in Table 3. The inverse association between national GDP and pollution reduction (e.g., decreasing CO₂) is, however, not universal.

Table 4 shows that the renewable energy score is 0.057 value can be seen for the coefficients of per capita education spending (PCEDU), whereas coefficients of per capita for research and development (PCRD) are recorded at 0.022 and 0.073, respectively. An evident heterogeneous effect can also be observed from Fig. 1. The low GDP per capita countries represented here tend to have a reasonable estimate regarding composition and technical effects. The coefficient of low GDP per capita countries for education expenditure is recorded at 0.215. This value is significant at a level of 1%. However, the value of the coefficient for high GDP per capita countries is recorded at 0.049 (see Fig. 3). This value is significant at 5% level. A GDP per capita-based split analysis on the whole sample is explained in this section. The two sub-divisions of the sample include the countries with low GDP per capita and a high GDP per capita (Agyekum et al. 2021; Zhang et al. 2021). The three non-parametric tests applied include the rank-sum equality, equality of distribution and rank comparison.

Table 3 ADF and PP results

Constructs	Level		1st difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
Panel I: ADF—Fisher/chi-square				
Ln (Y)	18.75 (0.8723)	13.07 (0.2217)	22.64 (0.4412)	1.65 (0.2711)
Ln (λ 1)	0.26 (0.3467)	0.11 (0.000)	5.66 (0.8888)*	4.89 (0.0737)*
Ln (λ 2)	11.37 (0.2865)	9.49 (0.2371)*	17.21 (0.9724)*	4.93 (0.0000)*
Ln (λ 3)	10.68 (0.7777)	6.66 (0.000)*	15.78 (0.0052)	3.05 (0.4391)*
Ln (λ 4)	16.27 (0.3461)	10.01 (0.5728)	37.19 (0.1045)	6.88 (0.0061)*
Ln (λ 5)	6.028 (0.3544)	0.89 (0.3410)*	21.71 (0.1838)*	5.94 (0.0084)
Ln (λ 6)	9.734 (0.2971)	3.13 (0.000)*	13.13 (0.2878)	5.15 (0.0007)*
Ln (λ 7)	6.001 (0.3064)	0.10 (0.7321)	52.68 (0.5519)*	10.63 (0.1202)
Ln (λ 8)	7.237 (0.8275)	2.15 (0.0016)*	10.42 (0.0569)*	0.97 (0.1172)*
Ln (λ 9)	8.666 (0.5601)	4.80 (0.5388)	13.27 (0.0000)*	7.56 (0.2105)*
Panel II: PP Fisher/chi-square				
Ln (Y)	27.61 (0.8831)	31.14 (0.8813)	10.38 (0.2020)	7.004 (0.1476)
Ln (λ 1)	32.45 (0.0200)	11.81 (0.4934)*	15.67 (0.7142)*	14.75 (0.1789)
Ln (λ 2)	11.99 (0.7684)	6.07 (0.4672)	16.79 (0.1421)*	11.23 (0.6216)*
Ln (λ 3)	4.525 (0.3308)	0.05 (0.0000)*	28.19 (0.2489)*	18.88 (0.3604)
Ln (λ 4)	7.067 (0.4006)	2.17 (0.3419)*	17.71 (0.2676)*	20.71 (0.2013)*
Ln (λ 5)	13.01 (0.4250)	7.19 (0.1111)*	19.56 (0.1431)*	12.57 (0.0365)*
Ln (λ 6)	21.01 (0.3111)	8.35 (0.0007)	21.17 (0.0006)*	0.019 (0.000)*
Ln (λ 7)	37.92 (0.0000)	4.07 (0.1489)*	35.10 (0.7893)	9.47 (0.1827)*
Ln (λ 8)	12.55 (0.6803)	0.14 (0.5617)*	32.13 (0.5637)*	5.08 (0.6802)*
Ln (λ 9)	19.29 (0.5557)	0.56 (0.3418)*	14.07 (0.4190)	0.05 (0.9992)*

Table 5 suggests that climate change can have substantial impacts on normal market practices. A large rise in electricity consumption has been induced by the population as well. Another input parameter estimated in the model, this time, the G7 countries gave a response of 99.37% (Table 5), demonstrating the broad variety of economic data forecasts correlated with climate change mitigation. As a result, CO₂ emission measurements from the same nation have a high degree of homogeneity over time, implying that heterogeneity within countries accounts for over 99% of CO₂ emissions over time. This implies that countries' CO₂ pollution policies should not shift with time. That is, CO₂ emissions from the previous year represent CO₂ emissions in the subsequent year for the same region. McDonough et al. (2018) observed that CO₂ emissions at time t-1 are the key drivers of the shift in CO₂ emissions at time t. Contrary to common opinion, the E7 countries are seeing fewer volatility in GDP (overall) as a consequence of climate change(s) (Li et al. 2021b; Chien et al. 2021c; Iqbal et al. 2021a).

Long-run dynamics

To estimate the long-run association among the study constructs, we applied FMOLS technique. Our findings reported

the growth function in Table 6. It seemed that cleaner environment or in other words climate change mitigation in terms of CO₂ emission reduction has positive impacts on economic growth of BRI project and G7 and E7 region countries. Importantly, renewable energy sources have significantly moderated in this relationship and inclined the role towards positive extent. However, the role of green financing in terms of renewable energy source usage has a commendable role. All the countries of E7 and G7 regions reported the relationship between variables as significant. This commends a significant role of green financing techniques through renewable energy sources for environmental cleaning and greening. Such results validated the growth hypothesis, suggesting a unidirectional causality relationship between environmental cleaning and economic growth of G7 and E7 regions. This suggest more that using innovative energy solutions for the energy consumption holds a vital role in regional economic growth and climate change mitigation, directly and indirectly (Zhang et al. 2021).

As a consequence, the panel findings remained relevant in two ways: first, construct-wise, and second, country-wise. Since the residual errors are usually distributed, we can trust the findings recorded by the models, which are 1% for the lower percentiles and 99% for the higher percentiles. Floods endanger

Table 4 Cointegration results

	Y model (economic growth function in E7 countries)		CE model (environmental function in E7 countries)		Y model (economic growth function in E7 countries)		CE model (environmental function in E7 countries)	
	Statistics	Significance	Statistics	Significance	Statistics	Significance	Statistics	Significance
Within-dimension								
Panel v-statistic	5.21	(0.000)*	11.49	(0.000)*	10.65	(0.000)*	32.04	(0.000)*
Panel rho-statistic	- 7.74	(0.000)*	10.87	(0.000)*	17.17	(0.000)*	22.31	(0.000)*
Panel PP-statistic	- 23.76	(0.000)*	10.65	(0.000)*	14.57	(0.000)*	46.01	(0.000)*
Panel ADF-statistic	17.8	(0.000)*	14.18	(0.000)*	20.69	(0.000)*	25.16	(0.000)*
Panel v-statistic (weighted statistic)	14.67	(0.000)*	4.39	(0.000)*	12.03	(0.000)*	19.15	(0.000)*
Panel rho-statistic (weighted statistic)	-9.41	(0.000)*	15.46	(0.000)*	19.4	(0.000)*	19.95	(0.000)*
Panel PP-statistic (weighted statistic)	14.9	(0.000)*	17.12	(0.000)*	22.89	(0.000)*	15.79	(0.000)*
Panel ADF-statistic (weighted statistic)	10.12	- 0.4729	13.06	(0.000)*	31.15	(0.000)*	8.03	(0.000)*
Between-dimension								
Group rho-statistic	2.01	- 0.8542	2.04	- 0.7932	2	- 0.05819	2.02	- 0.6643
Group PP-statistic	- 2.18	(0.3287)*	- 3.47	- 0.7932	- 4.94	(0.0000)*	- 2.1	(0.2199)*
Group ADF-statistic	- 2.29	(0.3496)*	- 4.61	(0.6819)*	- 4.07	(0.0000)*	- 2.18	(0.2018)*

48% of the world’s property, more than half of the world’s people and 46% of global properties. In 68% of coastal regions, tidal and storms will cause flooding, while the remaining 32% is at risk from a regional increase in sea level, according to his report. The study also reveals the flow of green finance in G7 and E7 nations. The developing countries are host to the bulk of the world’s population. In 2018, the total and nominal GDP of the world’s population was projected to be about \$6.5 trillion,

with about 1.5 billion people. While having a population that is larger than China, their GDP is comparable to China’s. This level of magnitude revealed that 0.34 represents a 1% increase in economic growth due to green energy demand, resulting in a 0.11 increase in economic growth from where it is now. As a consequence, our results are compatible with previous research on E7 and G7 regional initiatives in multiple contexts, highlighting the role of a cleaner environment in economic

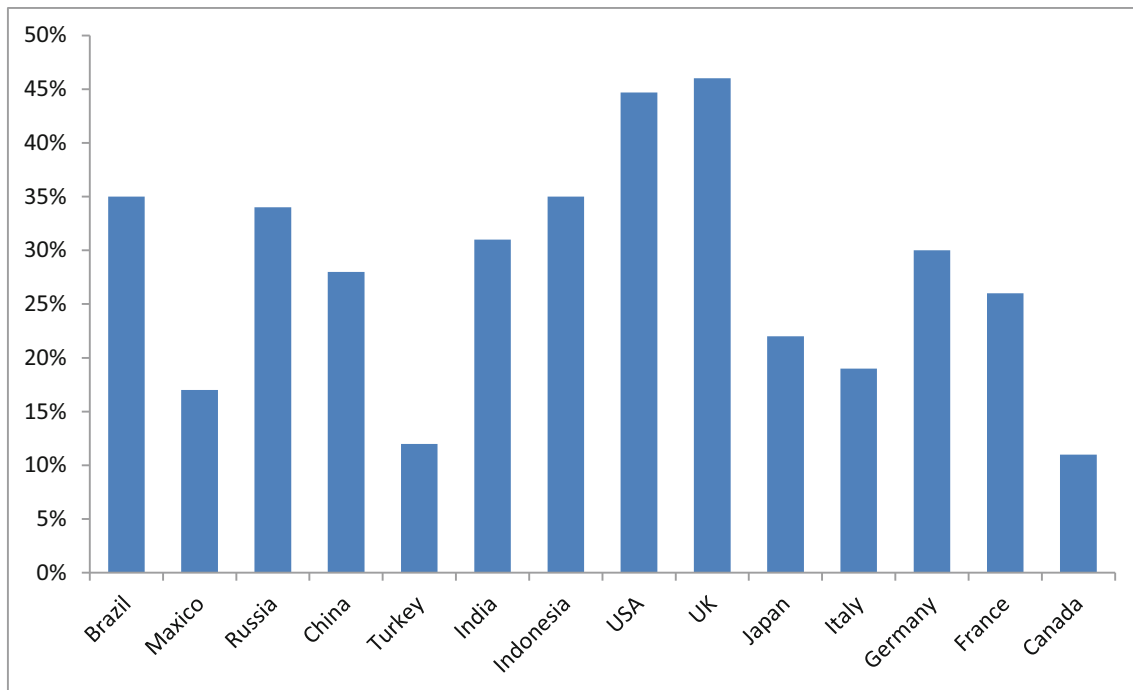


Fig. 1 Synthesis of climate change-GDP relationship

Table 5 Split outcomes of G7 and E7 countries on the basis of GDP

	GDP per capita G7 countries		GDP per capita E7 countries	
	1	2	3	4
L.GEGI	- 0.075* (0.039)	0.057*** - 0.037	- 0.060** - 0.03	- 0.061* - 0.03
PCRD	0.063*** (0.025)		0.025 - 0.026	
PCEDU		0.215*** (0.036)		0.049** - 0.033
INDUS	- 0.298*** (0.99)	- 0.208** (0.96)	- 0.460*** (0.086)	- 0.375*** (0.079)
Green	0.013 (0.064)	- 0.021 (0.062)	0.046 (0.033)	0.049 (0.030)
GDPPL	- 0.000 (0.018)	0.009 (0.019)	0.053** (0.025)	0.052*** (0.016)
Openness	- 0.027* (0.021)	- 0.010 (0.018)	0.012 (0.017)	0.024* (0.018)
Constant	3.612*** (0.574)	3.789*** (0.578)	3.735*** - 0.543	3.741*** - 0.454
Observations	108	108	144	144
Arellano-bond AR (1)	- 5.037 [0.000]	- 5.046 [0.000]	- 5.412 [0.000]	- 5.360 [0.000]
Arellano-bond AR (2)	0.719 [0.507]	0.809 [0.438]	-0.076 [0.856]	- 0.086 [0.834]
Sargan test	144.737 [0.780]	146.655 [0.756]	150.593 [0.727]	150.341 [0.736]

development by green finance on regional scales such as the G7 and E7. We have used the effects of the environmental feature with the growth function, as seen in Table 7, utilizing the

FMOLS technique. These findings indicate that CO₂ levels are elastic as green energy is used in combination with G7 economic development.

Table 6 Long-run estimates of the growth function

Countries	Growth function			Durbin-Watson
	<i>LnClim</i>	<i>LnEco</i>	<i>LnSoc</i>	
Brazil	0.024 (0.000)*	0.016 (0.000)*	0.004 (0.000)*	0.317 (0.000)*
Mexico	0.029 (0.000)*	0.022 (0.000)*	0.061 (0.000)*	0.209 (0.000)*
Russia	0.020 (0.000)*	0.044 (0.000)*	0.035 (0.000)*	0.111 (0.000)
China	0.041 (0.000)*	0.027 (0.000)*	0.317 (0.000)*	0.478 (0.000)*
Turkey	0.039 (0.000)*	0.059 (0.000)*	0.023 (0.000)*	0.400 (0.000)*
India	0.019 (0.000)*	0.028 (0.000)*	0.004 (0.000)*	0.307 (0.000)*
Indonesia	0.033 (0.000)*	0.047 (0.000)*	0.026 (0.000)*	0.369 (0.000)*
USA	0.018 (0.000)*	0.036 (0.000)*	0.040 (0.000)*	0.040 (0.000)*
UK	0.009 (0.000)*	0.014 (0.000)*	0.016 (0.000)*	0.025 (0.000)*
Japan	0.002 (0.000)*	0.010 (0.000)*	0.013 (0.000)*	0.011 (0.000)*
Italy	0.034 (0.000)*	0.048 (0.000)*	0.011 (0.000)*	0.014 (0.000)*
Germany	0.017 (0.000)*	0.031 (0.000)*	0.015 (0.000)*	0.002 (0.000)*
France	0.030 (0.000)*	0.058 (0.000)*	0.002 (0.000)*	0.011 (0.000)*
Canada	0.017 (0.000)*	0.044 (0.000)*	0.020 (0.000)*	0.063 (0.000)*

*shows level of significance at 5% level of confidence interval

Table 7 Robustness of results using panel VECM results for the growth function

Dependent variables		F-statistics								T-statistics ECT (- 1)
		λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	λ_8	λ_9	
λ_1	-	3.17*	2.64*	1.16*	2.45*	2.77*	3.19*	3.07*	3.70*	0.014 (0.000)*
λ_2	0.025*	-	0.78*	1.19*	1.50*	1.67*	1.90*	1.50*	1.01*	0.018 (0.000)*
λ_3	0.017*	0.029*	-	0.44*	0.35*	0.31*	0.10*	0.23*	0.05*	0.025 (0.000)*
λ_4	0.027*	0.036*	0.047*	-	0.49*	0.34*	0.218	0.16*	0.16*	0.037 (0.000)*
λ_5	0.023*	0.041*	2.054*	4.037*	-	0.21*	0.01*	0.14*	0.23*	0.021 (0.000)*
λ_6	0.034*	1.038*	1.190*	1.275*	2.67*	-	0.11*	0.04*	0.06*	0.014 (0.000)*
λ_7	0.030*	1.054*	2.01*	2.55*	2.69*	2.88*	-	0.09*	0.01*	0.037 (0.000)*
λ_8	0.017*	0.54*	0.67*	14.63*	17.01*	12.99*	15.04*	-	1.73*	0.044 (0.000)*
λ_9	0.011*	0.027*	0.030*	1.45*	1.50*	1.71*	3.63*	4.44*	-	0.005 (0.000)*

Green performance index

Interestingly, there is slight difference of graphs between E7 and G7 countries, but comparatively G7 countries are more inclined to take initiatives for climate change mitigation. As Brazil holds lower score ranging from 46 to 54% which is the lowest score in E7 countries, as well as in G7 countries. Mexico has good index in terms of green performance which is greater than 75%. China is setting a benchmark in green performance index achieving more than 93% score to perform green. Indonesia is sluggish to perform as green countries holding score less than 60%, which is quite alarming and indicates to take quick actions for a secure environmental future, nationwide, while in G7 countries, only France is less efficient to perform green and having score less than 60%. Conclusively, G7 has one country (e.g. France) and E7 has two countries (e.g. Brazil and Indonesia).

The G7 and E7 countries must strive to emphasize the value of natural resources' effect on global growth and financial development. A 7% growth in export leads to a 45% rise in financial deepening, according to his calculations. Despite the fact that it is mostly based on fossil fuels, this research may be particularly useful for the E7 and G7 countries in terms of consuming renewables and developing their financial sectors. Between 2011 and 2018, the six MDBs donated a total of 237 billion dollars to developed countries in the battle against climate change. Multilateral development banks (MDBs) have recorded a 61% growth in climate financing from 18% to 29% since 2013. In 2018, the MDBs pledged \$165 million to graphht climate change, totalling US\$ 21,439 million, with 71% of it heading to construction loans and the remaining 7% going to policy-based funding, totalling US\$ 2,195 million.

Figure 2 and Fig. 3 show the climate change mitigation in E7 and G7 countries. Li et al. (2021d) stressed the importance of filling the \$110 billion annual deficit left by MDBs,

concentrating on green finance in Latin America and the Caribbean. According to the report, an extra \$7 billion in green funds and \$4.4 billion from MDBs can be spent next year.

Discussion

The aim of this analysis was to look at the impact of climate change mitigation on GDP in the E7 and G7 nations, as well as other determinants including environmental taxation, human resources, GDP, green energy use and environmentally sustainable technical innovation. For a variety of factors, we decided to analyse a sample of G7 and E7 nations. The strategy, strategies and activities of these seven great powers, which control nearly half of global GDP, are critical in achieving low CO₂ levels. G7 countries' attempts to curb CO₂ pollution are commendable, given that their exposure to greenhouse gas emissions was 70% in the early twentieth century and just 24% in 2015. Despite the fact that its absolute contribution to greenhouse gas emissions is high, the G7's contribution is just half that of China as of early 2010. Canada has the largest greenhouse gas emissions and electricity use per capita in the E7 nations.

As long as it proceeds to subsidies the use and output of fossil fuels, Canada's success in climate change mitigation policy is rated as average. Furthermore, the UK, Indonesia and Germany have excellent results in terms of greenhouse gas emissions and oil usage, while the USA and Japan have poor efficiency. By examining the non-homogeneous features of regional nations, such as E7 vs. G7, the study seems appealing. The results of this analysis can be used to advise relevant strategies for a balanced world by the great powers. The research constructs are bidirectional between climate change mitigation (e.g. CO₂ emissions) and economic growth in the G7 and E7 areas, according to the long-run calculation parameters. These results back up the study's hypothesis that

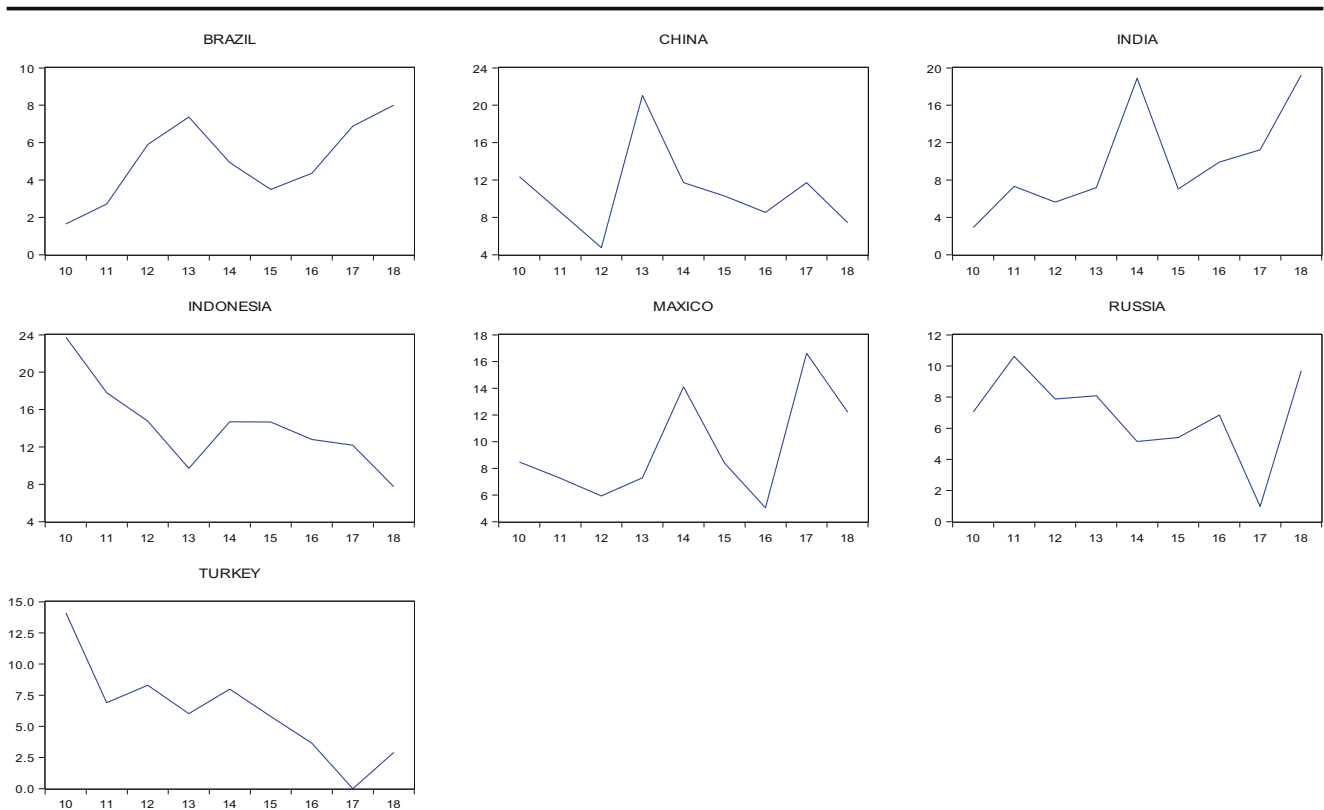


Fig. 2 Climate change mitigation performance of E7 countries

there is a beneficial connection between a cleaner atmosphere (e.g. climate change mitigation) and economic development and that green finance strategies will help improve the G7 and E7 region's natural, economic and social well-being.

Thus, the study hypothesis is accepted, and through these estimates, our study findings are robust in the long run. The results of the recent study are aligned with the findings of Abbas, (2020) for regional dynamics and in the long-run

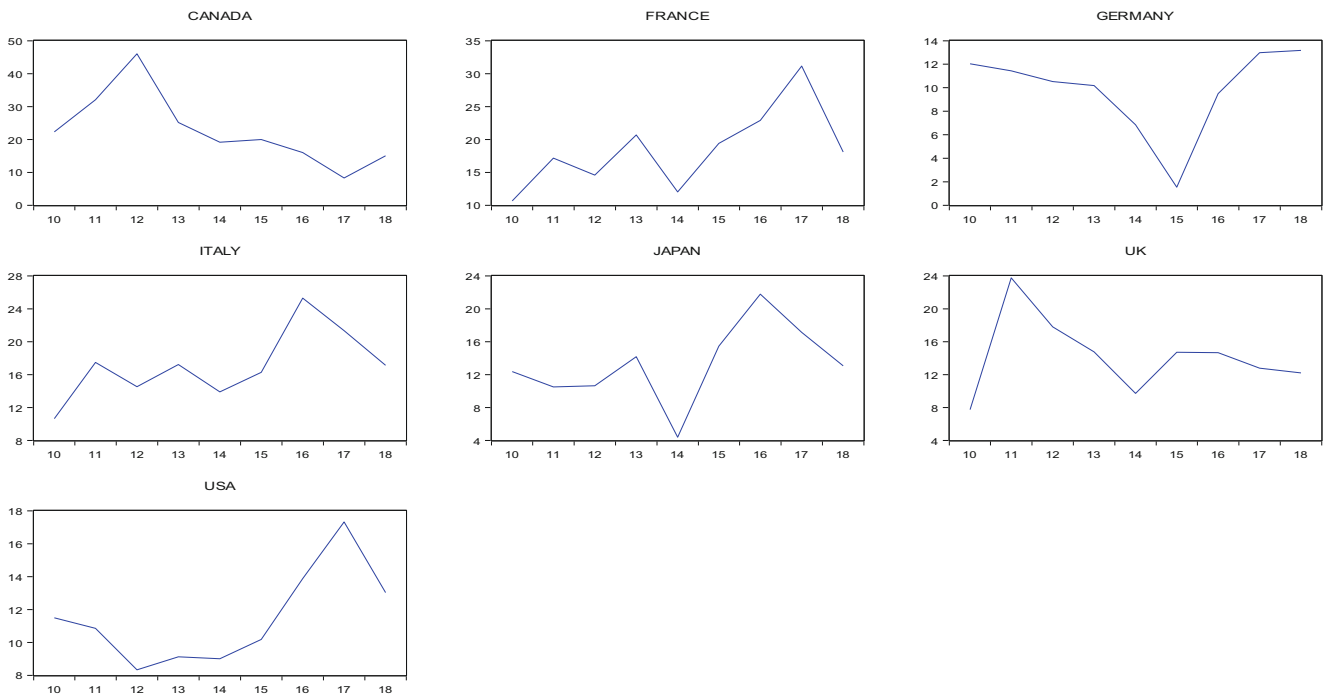


Fig. 3 Climate change mitigation performance of G7 countries

Table 8 Green performance index of E7 and G7 countries

Region	Countries	2010	2011	2012	2013	2014	2015	2016	2017	2018
E7 countries	Brazil	0.47	0.46	0.45	0.46	0.45	0.47	0.51	0.52	0.54
	Mexico	0.76	0.76	0.75	0.73	0.73	0.79	0.83	0.81	0.83
	Russia	1	1	1	0.97	0.98	1	1	1	1
	China	0.93	0.93	0.95	0.98	1	1	1	1	1
	Turkey	0.62	0.74	0.5	0.65	0.75	0.71	0.90	0.78	0.84
	India	0.67	0.71	0.69	0.79	0.79	0.84	0.73	0.77	0.76
	Indonesia	0.58	0.73	0.72	0.62	0.58	0.58	0.58	0.58	0.58
G7 countries	USA	0.66	0.65	0.65	0.67	0.66	0.65	0.66	0.67	0.69
	UK	0.95	0.95	0.95	0.85	0.78	0.78	0.8	0.77	0.65
	Japan	0.87	0.88	0.87	0.88	0.88	0.85	0.84	0.84	0.85
	Italy	0.76	0.75	0.73	0.75	0.67	0.68	0.68	0.67	0.65
	Germany	0.95	0.86	0.84	0.80	0.85	0.87	0.95	0.95	0.95
	France	0.46	0.50	0.49	0.49	0.48	0.5	0.53	0.52	0.55
	Canada	1	1	1	1	1	1	1	1	1

context. Note: * means significance at the 5% stage. We concluded the empirical outputs of study with growth function by using VECM approach shown in Table 8 indicating bidirectional causality among the cleaner environment and green financing potential, in the long-run, endorsing. Our results are in line with the conclusions of Bocco et al. (2020). Contradicting to it, the findings of the study are comparatively consistent with different other studies (Wahab et al. 2020), supporting the unidirectional findings of recent study, missing the link to predict the long-run future of any BRI project in a region that is covered by recent study. By this, current investigation sufficiently fills the gap on theoretical, empirical and practical grounds by providing key policies suggestion for policymakers.

In this sense, the International Institute for Applied Systems Analysis (IIASA) predicts that South-eastern, Central and Western Asia will become major economic drivers (i.e. the BRI countries will account for 50% of global GDP from 2015 to 2030). It has a worldwide market share of 11%. These figures demonstrate the G7 and E7 countries' expenditure and demand capacity. An analysis by shows a long-term equilibrium association between population, technical change and sustainable use for G7 vs. E7 countries. As facility access is a necessity in the introduction of the BRI, a growth in per capita GDP would result in a major increase in electricity demand and carbon emissions.

Conclusion and policy implications

This research suggested an examination of various approaches to changing green finance and environment conditions in G7 and E7 countries from 2010 to 2018. To measure the impact of climate change and green finance mitigations on the countries

under consideration, two classes of countries have been created (i.e. treated group and control group). To contend with the unobserved time variation, which may trigger weakness in the inference, pre-treatment observables have been used by matching approaches (i.e. the kernel, radius matching and nearest neighbour approach). This strategy may help to offset the time gaps between classes. The E7 countries are the twenty-first century's fastest-growing economies. China has the world's largest clean energy assets, including hydropower, solar PV and wind. With a 15% renewable energy goal for 2020, China has been investing in renewable energy for a long time. By 2018, it had reached 14.3%, with a total expenditure in renewables of 33%. Furthermore, low-carbon solutions are expected to meet about 40% of the country's renewable energy expenditure requirements, including transportation, whereas wastewater, land remediation, waste management and sewerage will get the remaining 60% from 2014 to 2020 (Shahzad et al. 2021). The G7 and E7 countries account for 7.94% of the world GDP and produce around 11.2% of global CO₂ emissions. The burden-sharing issue requires that the developed and the developing world take equal constructive measures to prevent practices that would increase global temperatures above 1.5 °C as foreseen by the Paris Accord (Sinha et al. 2020).

This research highlighted the importance of G7 and E7 countries developing policies capable of addressing systemic risks associated with climate change, as well as the necessary funding to mitigate these risks and impacts. Based on the methodology used, the analysis yielded mixed results, as there is no correlation between the G7 and E7 countries' green finance and climate risk profiles. For emerging and developing economies (EMDEs), in particular, sustainability is a critical concern. Overall, the following indicators have a major influence sample country: the continent's EE condition,

foreign direct investment, GDP, oil imports, energy-related pollution, fossil fuel use, port infrastructure efficiency, logistic output index and taxes. However, various models showed that certain factors had different effects on EE. Furthermore, projections of the marginal impact suggest that oil imports are unlikely to disrupt the G7 and E7 countries' EE.

1. The existing assessment techniques for energy, pollution and economy need to be replaced with completer and more low-cost (in terms of time) indicators for better assessment of real-time data and enforcement of local and international energy laws.
2. Authorities need to redistribute public funds towards the public good. Although public funds, R&D and education for clean energy have been raised lately, they are not comparable to developed countries. Governments should allocate additional funding to green energy education and R&D in the light of the findings of this study, which will proliferate human resource mobilization and technology innovation, critical to green economic success.
3. This work highlights country-wide variation in the effects of public funds on green economic growth. Therefore, E7 and G7 economies are recommended to formulate country-specific strategies for better benefit.

Authors' contribution Wu Xueying: Conceptualization, writing—original draft. Muhammad Sadiq: writing—original draft. FengSheng Chien: Data curation, methodology. Thanh Quang Ngo: Data curation, visualization, review and editing. Anh-Tuan, Nguyen: Writing—review and editing and software. The-Truyen, Trinh: Visualization, supervision, editing and software.

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Data Availability The data that support the findings of this study are openly available on request.

Declarations

Ethical approval and consent to participate We declare that we have no human participants, human data or human tissues.

Consent for publication We do not have any individual person's data in any form.

Competing interests The authors declare that there is no conflict of interest.

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