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RESEARCH ARTICLE

Nexus between green finance and climate change mitigation in N-11 and BRICS countries: empirical estimation through difference in differences (DID) approach

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Abstract
Green finance is inextricably linked to investment risk, particularly in emerging and developing economies (EMDE). This study uses the difference in differences (DID) method to evaluate the mean causal effects of a treatment on an outcome of the determinants of scaling up green financing and climate change mitigation in the N-11 countries from 2005 to 2019. After analyzing with a dummy for the treated countries, it was confirmed that the outcome covariates: rescon (renewable energy sources consumption), population, FDI, CO_2, inflation, technical corporation grants, domestic credit to the private sector, and research and development are very significant in promoting green financing and climate change mitigation in the study countries. The probit regression results give a different outcome, as rescon, FID, CO_2, Human Development Index (HDI), and investment in the energy sector by the private sector that will likely have an impact on the green financing and climate change mitigation of the study countries. Furthermore, after matching the analysis through the nearest neighbor matching, kernel matching, and radius matching, it produced mixed results for both the treated and the untreated countries. Either group experienced an improvement in green financing and climate change mitigation or a decrease. Overall, the DID showed no significant difference among the countries.

Keywords Difference in difference · CO_2 · Economic development · Probit regression · N-11 and BRICS countries

Introduction

Climate risk is investment risk. Green finance is the panacea to dealing with these risks. Green finance became popular in the 1980s and continues to attract attention globally. Green finance explains the situation whereby business objectives are achieved while considering environmental benefits. Contrary to the conventional financial transaction, green finance has to do with environmental activities that protect the environment from degradation (Wang and Zhi 2016). The

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scientific evidence from climate change is so conspicuous that the world needs to act now to avert disastrous consequences. As a result, green finance is a cornerstone instrument to curb the existential threats of climate change. The central banks have long considered the issue of climate change–associated risks to financial system stability in recent times and financial regulators (Gagnon and Sack 2018). The term green economy gained prominence after the 2008/2009 financial crises, where the world seized the recovery opportunity to bridge the gap brought by the economic recession and to implement policies to address these inequalities and reduce environmental concerns, thus, the term green economy (Mohsin et al. 2018a, b). In revamping their economies after the recession, China, South Korea, and the USA called their stimulus packages "the Green New deal." The aim was to jumpstart their economies to a sound recovery and putting their economies on a sustainable recovery pathway (Georgeson et al. 2017).

The corona pandemic presents an opportunity for the N-11 countries to recover sustainably and transition to a sustainable future. According to the IEA, the global economy will be reduced by 6% in 2020, with over 300 million jobs lost (Sustainable recovery, 2010). But IRENA (2020) says for the world to recover sustainably and move out of these economic predicaments, the world needs to invest about $2 trillion in the post-COVID-19 2021–2023 recovery phase in green investment projects such as renewables. The investment, coupled with institutional investment and green bonds and dedicated funding, would be crucial for a sustainable recovery (IRENA 2020). The N-11 countries have the opportunity to green their recovery outlook, whether it is W-shape or V-shaped. The COVID-19 has already reduced CO_2 emissions but lowered economic growth with its commitment to economic hardships and human suffering.

Sinha et al. (2018), in their research, referring to Arifin and Syahruddin (2011), revealed that Indonesia could increase the growth of their economy, from 1971 to 2008, when they increase the consumption of renewables and reduce fossil fuel consumption. Furthermore, Indonesia targets to go green by generating 5% of its electricity from geothermal sources; 5% wind, biomass, hydro, and solar; and 5% biofuel by 2025 (Hezri and Hofmeister 2012). In a significant work to advance the course of Indonesia to a low-carbon economy, the country launched the low-carbon development initiative (LCDI), with the high case scenario to deliver a suite of policies and scalable actionable transforming programs in the different sectors of the economy. These interventions will achieve consistent 5.6% economic growth by 2024 and 6.0% by 2045. In a high case scenario, about $5.4 trillion would be added to the GDP by 2045, more than 15.3 million decent green additional jobs. As well as a reduction in the poverty rate of 9.8% of the total population of 2018 down to 4.2% and saved 40,000 lives as a result of improved air quality (Brodjonegoro et al. 2019). The Philippines plans to ramp-up 100% of its renewable capacity in 2015. The Philippines buoyed by a growing economy of 6.6% for the last 6 years; the country plans to install 2.35 GW of wind capacity by 2030, out of its theoretical potential of 76 GW (Lee and Zhao 2020). Another booming economy is Vietnam, with a 6% GDP growth of about a decade now, which has RE targets 5% in 2020 and 11% in 2050 (Hezri and Hofmeister 2012). Vietnam currently has an installed wind capacity of 228 MW and plans to install 800 MW by the end of 2020 (Lee and Zhao 2020). It has been suggested by Yildirim et al. (2014), the N-11 countries have quite high energy intensity ratios, which makes it imperative for them to consider investing in energy efficiency and conservation and ultimately greening their economies. While the rest of N-11 countries have similar traits regarding their economic structures, Nigeria is grappling with low energy access and expects to green its energy mix by one fifth in a decade to come (Sinha et al. 2018); Turkey has geopolitical issues with the EU; Pakistan is undergoing reforms in its financial sector as well as the energy sector.

Across the world, both the private and public sectors have recognized the urgent need to implement policies aimed at fighting the risks posed by climate change and environmental degradation, and also reaping the economic benefits that come as a result of providing solutions to these risks (Kaminker and Majowski 2018). Another source of green finance is through green bonds, where the proceeds are used to finance green projects like renewable energy, other than a carbon pricing system (Baker 2018). The green bond market had grown significantly since 2007 when it was first issued by the European Central Bank (ECB) (Baker 2018). Another characteristic of the N-11 countries is that they are grappling with rising energy demand that needs substantial investment as well as heavy industries that are not energy efficient in producing goods, and this has damning environmental consequences (No and Padhan 2018). Green finance and, for that matter, climate change consequences are no longer a niche issue facing the developed world. It has global ramifications (Mohsin et al. 2020a) and (2020b).

Thus, this study seeks to analyze the factor that will determine the catalyzing of green finance by the N-11 and BRICS countries and their climate change mitigation strategies. Renewable energy consumption is used as a proxy for green finance. In doing this, the difference in differences (DID) approach is applied for the N-11 countries from 2005 to 2019. The treatment period starts from 2010 to 2019 for the treated countries. This model contains two time periods the "before" and "after" and two groups "treatment" and "control." The model analyzes variations between two groups that receive treatment at different times. Thus, the N-11 countries were treated, and the BRICS countries were controlled. The benefits of using the DID far outweigh that of the disadvantages: it is easy to calculate the standard errors, it is easy to include different periods, and we can control for other variables to avoid biased estimates of the coefficients.

The contribution of our study is to the best of our knowledge, and it is the only paper that uses the DID method to analyze green energy finance and climate change mitigation among N-11 countries for the period 2000–2019 and the BRICS. A couple of studies have been done on N-11 countries such as Sinha et al. (2020), Padhan et al. (2018), Yildirim et al. (2014), and Erdoğan, Yıldırım, et al. (2020). All these applied an econometric method in their analysis. However, the difference in our study lies in that we used the difference in differences approach (DID) for analyzing both BRICS countries and N-11 countries. The findings show that FDI, R&D, technical corporation grants, CO_2, POP, Human Development Index, renewable energy consumption, as the covariates, have significant outcome effects on green financing and climate change mitigation strategies for these countries. The matching method of next neighbor matching, kernel matching, and radius matching produced mixed results for the treated and the untreated countries. On the whole, there were no significant differences among the countries.

The rest of the paper is organized as follows: The next section presents an overview of the status of green and climate change mitigation on the N-11 countries and the BRICS. The "Data and methodology" section is the methodology that is employed in the analysis, the "Results and discussion" section is results and discussion, and the "Conclusion and policy implication" section concludes the study.

Literature review

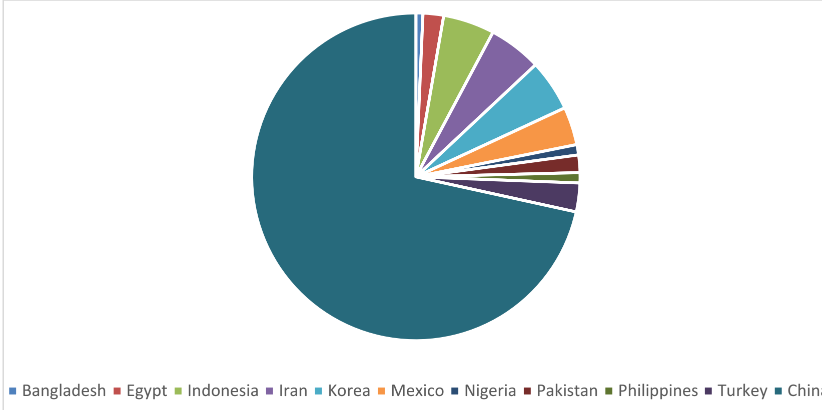
Green finance includes climate finance but is not limited to it. It also refers to a wider range of other environmental objectives, for example, industrial pollution control, water sanitation, or biodiversity protection. The mitigation and adaptation finance pertain to climate change–related activities: financial mitigation flows refer to investments in projects and programs that contribute to reducing or avoiding greenhouse gas emissions (GHGs) (Mohsin et al. 2019a, b), whereas adaptation financial flows refer to investments that contribute to reducing the vulnerability of goods and persons to the effects of climate change. Yildirim et al. (2014) estimated using a bootstrapped autoregressive metric causality approach, a more robust approach for N11- countries, detected a correlation between economic growth and energy consumption among these countries. They concluded that pro-energy conservation policies are implemented for Bangladesh, Egypt, Indonesia, Iran, Korea, Mexico, Pakistan, and the Philippines. Gozgor et al. (2020) investigated the economic globalization of 30 OECD countries from 1975 to 2015 and concluded that as one of their recommendations, the need to increase the knowledge of how economic globalization to spur renewable energy development, not only for OECD countries but also for other developed and developing countries alike (Iram et al. 2019; Mohsin et al. 2018a, b).

Across the world, countries are enacting policies to mitigate the risks brought by climate change and its environmental impacts. These include a suite of systems such as the issuance of green bonds to raise the needed green financing in fighting the exacerbating effects of climate change. The next N-11 is not left out. They are made up of eleven countries: Egypt, Bangladesh, Nigeria, Iran, Indonesia, Pakistan, Turkey, Mexico, South Korea, the Philippians, and Vietnam. Godman Sachs investment bank chose these as having the economic potential to become the biggest economies in the twenty-first century alongside the BRICS, in 2005. They exhibited opportunities for investment and growth (Bader Riyad ALOnaizi et al. 2017). The Next emerging countries (N-11) are facing climate change and its attendant problems. These existential challenges make it imperative to green the macroeconomic policies to fight the menace. Green finance integrates economic decisions with environmental decisions to arrive at optimally beneficial outcomes (Wang and Zhi 2016). The term green finance has been defined by Lindenberg (2014) to refer to "a broad term that can refer to financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy" (Mohsin et al. 2019a, b).

Similarly, a study (Paramati et al. 2018) applying panel data of 23 developed and 20 developing countries globally for the period 1991–2011 discovered that stock market developments have mixed effects on carbon dioxide reduction in these countries. They argued that it has led to the reduction of CO_2 emissions in the developed countries, due to the robust systems to curtail emission levels; however, the contrary is said of the developing countries where emission level reduction has not been achieved. This finding is revealing and calls on developing countries to green their stock portfolios by demanding listed companies to institute favorable environmental policies and increase the share of renewables in their energy consumption. A study by Xie et al. (2020) concluded that FDI has led to an increase in CO_2 emission levels in emerging countries (Fig. 1).

Furthermore, Erdoğan et al. (2020) studied the relationship between natural resources exports on economic growth and the level of financial deepening for selected N-11 for the period 1996–2016 and found that where financial deepening is over 45%, a unit increase in export brings about a 7% increase in economic growth. Even though this study pertains to fossil fuels, the N-11 countries stand to benefit if they apply this approach to the consumption of the renewables and green the financial sector. This will bring more than double the economic growth for the economies of these countries. In a study on developing carbon low finance index-based evidence on

Fig. 1 CO_2 emission



designing and developing countries, with two N-11 countries Mohsin et al. (2020a, b) asserted that developing countries would have to ramp-up efforts to scale up renewables in their respective countries. Iran and Pakistan as N-11 countries have the least scores for the financial index for low-carbon finance index. Hence, these countries must deepen their financial sectors by instituting mandatory policies to encourage the development of low-carbon financing derisking instruments to attract investments in emerging technologies (No and Padhan 2018) in a novel approach to determine the important factor N-11 countries face either economic growth or environmental quality, using panel data for the period 1971–2013. As one of their findings said, N-11 countries should take steps to curtail an increasing inequalities, by putting in policies like taxes to redistribute wealth to ensure inclusiveness and absorb some expenditures of the poor. These measures will ameliorate the plights of the poor due to the exacerbated inequalities created by economic growth.

Heine et al. (2019) in their recent paper said, transitioning to a low-carbon economy and therefore, mitigating climate change impacts demand the adoption and utilization of carbon pricing and green bonds. They argued the integration of these approaches would yield desirable outcomes that are political feasibly and environmentally sustainable. More so, in their analysis, Tolliver et al. (2020) found that the nationally determined contributions (NDCs) using the difference in difference (DID) analysis are statistically crucial to determining the allocation of proceeds of green bonds to renewables between 2008 and 2017 since they were formally submitted. They said, where there are stiffer NDCs, more proceeds from bonds were allocated to renewable energy assets and projects with a 99% significance level. Realizing the importance of climate finance, multilateral development banks (MDBs) have committed vast amounts of money into fighting this menace. The six MDBs have cumulatively allocated over 237 billion dollars to developing and emerging countries to fight climate change from 2011 to 2018.

Multilateral development banks (MDBs) have seen over 61% increases in climate finance ratio since 2013, from 18 to 29% (Tanner and Horn-Phathanothai 2019). In 2018, the MDBs committed \$30,165 million to fight climate change, with a whopping US\$ 21,439 million, representing 71% for investment loans and another 7% for policy-based financing with a total value of US\$ 2195 million. Yuan and Gallagher (2018) studied green finance in Latin America and the Caribbean countries, and emphasized the need to bridge the funding gap of \$110 billion per annum, which is not met by the MDBs. They further contended that the MDBs provided \$7billion for green funding, and that of climate change mitigation is \$4.4 billion per annum for these territories. Furthermore, it is discovered from their research that countries that have higher human rights records and pro-socialists tend to receive more green funding from the MDBs (Yuan and Gallagher 2018). Another groundbreaking study by Sinha et al. (2020) concluded the N-11 countries had faced hurdles to achieve the SDG aims as a result of not being able to maintain environmental quality. And that the N-11 countries have grown their economics at the expense of the environment.

Data and methodology

To determine the determinants of green financing for N11 countries and the mitigation of climate change, the difference in difference (DID) approach was applied to analyze the data from 2005 through 2019. The treatment period for the treated countries was from 2010 to 2019.

Data

In conducting the empirical analysis, data from the N-11 countries (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, Turkey, South Korea, and Vietnam) from 2005 to 2019 was used as well as data from BRICS countries (Brazil, China, India, Russia, and South Africa). This approach was chosen because the difference in differences methodology is applied in the analysis. The carbon dioxide emission levels are measured in kilotons (kt), GDP is (constant, 2017) US dollars, the population is measured in percentage (%), technical cooperation grants are measured in US dollars, foreign direct investment (FDI) (Fig. 2) is measured in USD, Human Development Index is measured in percentage, renewable consumption as a proxy for green finance is measured in kilotons (kt), inflation measured in percentage, GDP is measured in USD 2017 purchasing power parity (PPP), domestic investment private participation in the energy sector is measured in USD, and local credit to the private sector is measured in dollars as well. All these variables were obtained from the world development indicators.

The difference in differences estimator

To do the analysis, the widely use DID is used as applied by Upton and Snyder (2017), Abadie (2018), and Xu (2017). This approach is used with cross-section data or panel data availability for N-11 countries and BRIC countries for different periods. Primarily, the theoretical model for the DID is given as follows: The rationale for the choice of the DID is, it gives unbiased estimates of the coefficient of green finance in Africa, thus giving us reliable results. Suppose $y(i, t)$, which are the desirable outcomes for country i at time t. The countries are observed in before treatment period $t = 0$ and after treatment period $t = 1$. Around these two time periods, if a group of the countries are exposed to the treatment, they are assigned by $D = (i, t) = 1$. Similarly, if a particular country is exposed to the treatment period prior to t, $D = (i, t) = 0$ others not. $D = (i, t) = 0$ refers to countries that are not treated or untreated or controlled countries and $D = (i, t) = 1$ refers to countries that are treated in the study, the N-11 countries. The treated countries are the N-11 eleven countries. As a result, countries can only be exposed to the treatment $D = (i, t) = 0$ for i (Abadie 2018). The primary DID estimator is usually done using a linear parametric model. The estimating of the model is done regarding what is done in Card (1985) and Abadie (2018). Assume that the resultant variable is generated by the variance process in the equation below.

$$Y(i,t) = (i,t) = \delta\ (t) + \alpha.\ D\ (i,t) + \eta(i) + v(i,t), \tag{1}$$

From Eq. (1), $\delta\ (t)$ represents a time-specific component, α represents the impact of treatment, $\eta(i)$ represents a country-specific component, $v(i, t)$ connotes country-specific shocks that have mean zero within each period, $t = 0{,}1$ and is directly correlated in time. $y(i, t)$ and $D(i, t)$ are the observable variables.

$$P\Big(D(i,t) = 1|-(i,t) = P\Big(D(i,1) = 1 \tag{2}$$

$t = 0{,}1$. Doing addition and multiplication to $E[\eta(i)|D(i, 1)$ in Eq. (1), it becomes:

$$Y(i,t) = \delta\ (t) + \alpha.D\ (i,t) + \mathrm{E}\ [\eta(i)|\ D(i,1)] + \varepsilon(i,t), \tag{3}$$

From Eq. (3) $(i, t) = \eta(i)$- $E[\eta(i)]|\ D(i, 1)] + v(i, t)$. It should be noted that $\delta\ (t) = \delta\ (0) + (\delta(1) - \delta\ (o)t$,

And $E[\eta(i)]|\ D(i, 1)] = E[\eta(i)]|\ D(i, 1){=}0] + \mathrm{E}[\eta(i)]\ |\ D(i, 1) = 1]$ - $E[\eta(i)]\ |\ D(i, 1){=}0]\ D(i, 1)$. Let $\mu = E[\eta(i)]|\ D(i, 1){=}0] + \delta\ (0)$, $\tau = E[\eta(i)]|\ D(i, 1) = 1]$- $E[\eta(i)]|\ D(i, 1){=}0]$, and $\delta{=}(\delta(1) - \delta\ (o)$. Equation (4) is derived below:

$$Y(i,t) = \mu + \tau.D(i,1) + \delta.t + \delta.D(i,t) + \varepsilon(i,t). \tag{4}$$

The limitations put on Eq. (2) that sets $t = 0$, 1 signify $E[1, D(i, 1),t, D(i, t)$. $\varepsilon(i, t) = 0$. The variables in Eq. (4) as well as δ are estimable using an ordinary least squares (OLS) approach. The equation makes it possible for selecting treated countries based on dependence, given that $D(i, 1) = 1$ and country-specific variable $\eta(i)$. Equation (4) could be further simplified as given below:

$$Y_{it} = \delta + \delta_i \mathrm{TREAT}_i + \delta_i t \mathrm{POST}_t + \uparrow\beta^{2\times2} t \mathrm{TREAT}_i \times \mathrm{POST}_t + U_{it} \tag{5}$$

Y_{it} represents outcomes of the rescon, GDP, FDI, pop, R&D, CO_2, Human Development Index, inflation, technical

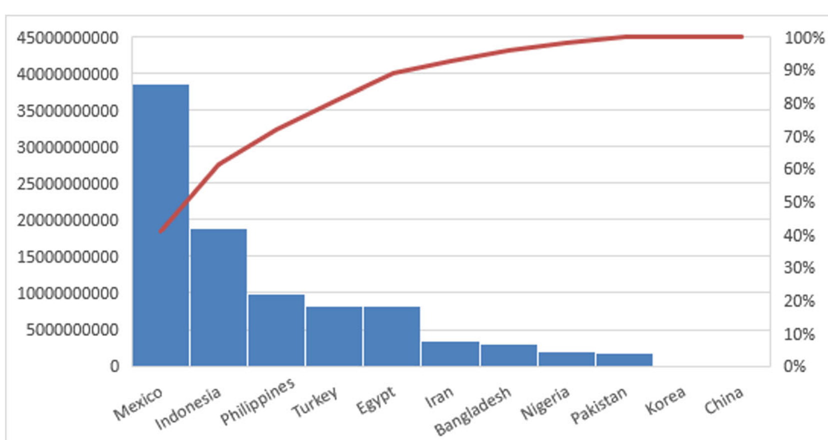


Fig. 2 Foreign direct investment

corporation grant, R&D, investment in PP, and domestic credit to the private sector. δ_iTREAT$_i$ represents countries that have been exposed to treatment at i, and $\delta_i t$POST$_t$ explains countries that have been exposed to the treatment after the treatment and $\beta^{2\times 2}t$TREAT$_i\times$POST$_t$+U_{it} is the interaction term for the treatment dummy of a group country and post-treatment dummy for a group of countries of the regression model. This part integrates the N-11 countries and BRIC that have been exposed to the treatment pre and after to find out the determinants of green finance and climate change mitigation. U_{it} is the serial unrelated country transitionary component of green investments in individual countries. This approach is called "difference in differences" (DID) and due to the given condition in Eq. (2), we now have Eq. (5) given below:

$$\delta = \{E[Y(i,1)|D(i,1)=1] - E[Y(i,1)|\, D(i,1) = 0]\} - \left\{E[Y(i,0)|\, D(i,1)=1] - E\left[Y(i,0)|\, D\left(i,1=0\right]\right\}\right) \quad (5)$$

The formulation of the model is necessary when dealing with cross-sections of $(Y(i,t), D(i,1))$ where $t = 0{,}1$. As a result of the study population using panel data, involving before and after difference among the countries, the outcome of the observation is given as $Y(i,1)$ $Y(i,0)$ and the δ is estimated by a conventional square method (OLS).

$$\delta = E\left[Y(i,1)-Y(i,0)|\,\right)|\, D(i,1)=1\Big] - E[Y(i,1)|\, Y(i,0)|\, D(i,1)=0]$$

Deducing from Eq. (2), $t = 0$, 1 means $v(i,1)$ - $v(i,0)$ is an average not depending on $D(i,1)$ and hence without treating of any of the countries, the mean outcomes would have the same variations as the treated countries. According to Abadie (2018), the limitation placed on the model maybe limiting if the treated and untreated groups have different unbalanced exploratory variables linked to the dynamics of the outcomes. In making an analogy to the pioneering work by (Ashenfelter's dip) Ashenfelter (1978) and avoid these variations among the study countries and take care of the heterogeneity among the countries, a model proposed by Ashenfelter and Card (1985) is proposed to accommodate these:

$$D(i,1) = \begin{cases} 1 \; if \; y = (i, 1-k) + u(i) < Y \\ 0 = \text{otherwise} \end{cases} \quad (6)$$

K is a positive integer, Y is a constant, $u(i)$ is a random variable. Under this scenario modeled above, individual countries that have low green finance and climate mitigation opportunities are likely to increase and adopt policies to spur them to increase their green finance and mitigate mitigation, after the treatment period, as a result of the demands of the Paris accord and environmental pressure group concerns. Furthermore, the DID is applicable on condition that$(i, 1-k)$. Hence, the impact on the treated group is given below:

$$\{E[Y(i,1)|X(i)\,), D(i,1) = 1\Big] - [Y(i,1)|\, Y(i,0)|\, D(i,1) = 0\Big]\Big\} - E[Y(i,0)|X(i)\, D(i,1)=1] - E[Y(i,0)|X(i)\, D(i,1)=0]\Big\} \quad (7)$$

From the ensuing equation, $X(i) = (i, 1-k)$. As in this article and that of Abadie (2018), $X(i)$ is a vector representing observable characteristics of individual countries, already determined at $t = 0$. Equation (7) deals with the matching order of the analysis. It compares each treated i group of countries to untreated individual countries. Linking to this to the outcome covariate Yi of treated Yi, a matched outcome by the estimated $\widehat{Y}_i$ is weighted to its neighbor in the comparison group. Therefore:

$$\widehat{Y}_i = \sum\nolimits_{j\in C^0(Pi)} w_{ij} y_j \quad (8)$$

$\boldsymbol{C^0}$**(*Pi*)** ***r***epresents a set of treated neighbors $\boldsymbol{i}$ in the group D = 0, $\boldsymbol{w_{ij}}$ stands for weight on untreated $\boldsymbol{i}$ in making a comparison with treated $\boldsymbol{i}$, hence.Generally, the matching estimator for the ATT ($\boldsymbol{S_{10}}$) can be***:***

$$\widehat{\text{ATT}} = \frac{1}{\#\left(D = 1 \cap (S_{10}\right)} \sum\nolimits_{i\in\{D_i = 1\cap S_{10}} \left\{ Y_i - \widehat{Y}_i \right\} \quad (9)$$

$$E\left(Y|\text{treated on } S_{10} - E\left(Y|\text{weighted/untreated}\right.\right.$$

Results and discussion

In analyzing how to determine and how to scale up green finance in N-11 countries, a normality test was done on the data, using the Jaque-Bera normality test to ascertain the skewness and kurtosis of the test. The test proved to be generally distributed with significance with a p value of 0.00, indicating the data is normality distributed. We, therefore, conclude that the residual errors are normally distributed. Table 1 gives a Stata analysis of the Jacque-Bera normality test. As a result, the difference in difference estimator was applied in analyzing the results. The advantages of using the DID approach are as follows: it enables us to compare only the comparable people. That is comparing apples with apples, not apples with mangoes. Again, it controls for unobserved and

Table 1 Summary statistics and normality test

Variable	Obs	Pr (skewness)	Pr (kurtosis)	adj_chi^2 (2)	Prob > chi^2
Residual	214	0	0.026	20.41	0
Variable	Obs	Mean	Std.Dev.	Min	Max
Rescon	216	24.628	23.637	00000	88.832
Gdppercapi~*r*	216	8.59E+11	1.86E+12	2279.531	9.23E+12
Inflationc~*l*	216	7.592	5.836	− 0.704	39.907
Rd	216	− 208.876	4242.534	− 31600	11590.63
Tcg	216	2.21E+08	1.60E+08	00000	9.59E+08
Pop	216	62.086	14.128	0.503	73.068
Fdi	216	6.41E+09	8.79E+09	− 4.83E+08	4.71E+10
CO2	216	860000	2020000	000000	1.03E+07
Investment~*u*	216	1.50E+09	3.38E+09	00000	3.45E+10
Hci	214	0.041	0.147	00000	0.845
Dctopsgdp	216	8.21E+08	3.55E+09	00000	3.03E+10

observable different characteristic impacts among the countries, as well as easy to be used in analyzing data and it is non-parametric in its approach.

Table 1 gives a summary of the descriptive statistics of the covariance and normality test. The GDP per capita mean score of the countries is the highest among the variables. Interestingly, research and development represent the number of people undertaking R&D in the countries is negative. This explains that R&D is negative and almost nonexistent in N-11 countries. FDI mean score is equally high as well as credit given to the domestic sector for the private sector in the energy sector. The R&D figure lends credence to the fact the private sector is very crucial in greening the energy sector and mitigating climate change effects on the planet. Expectedly, rescon that is renewable energy consumption in final energy consumption as aproxy of green investment has a lower mean score (Fig. 3).

The summary statistics for the treated and untreated group of countries is quite similar. But one crucial point worthy of note is that even though the same observations, the means are quite different in terms of numbers; the treated countries showed significant improvement in their green financing and climate change mitigation strategies. This is because the untreated grouped of 151 countries received a mean score of 26.532, and the treatment countries of 65 received a mean score pretty much close of 20.205. The score indicates a significant improvement after the treatment. The mean scores for GDP per capita, foreign direct investment, and domestic credit for private sector participation are equally very high. Of course, R&D is having a very low mean. The treated countries, on the other hand, have a higher mean score for the variables but the Human Development Index (HCI).

Table 2 depicts a dummy variable for the countries, as shown in Eq. (2). This is to provide a counterfactual argument to the hypothesis that countries will receive the same level of green funding, whether they are treated or not. The dummy is $D = 1$ for treated countries and $D = 0$ for untreated countries. The dummy proves significant with a p value of 0.000. This explains that countries that are exposed to the treatment, as well as those that are not exposed to the treatment, have a high propensity to attract green finances and implement climate change policies aimed at curbing its impact and transition to a sustainable development trajectory.

Table 3 above shows the regression output with a dummy covariate controlling for X. From the table, rescon, which is a proxy for green investment, has a significant correlation with GDP capita with purchasing power parity of US dollars, 2017 level. On the other hand, inflation per consumer price level is

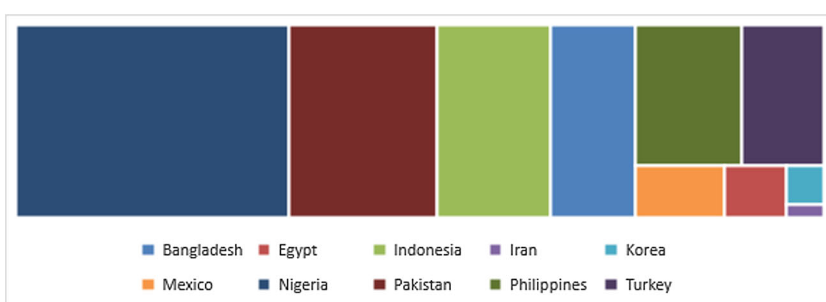


Fig. 3 Renewable energy

Table 2 Regression with a dummy variable for treatment (*t* test) *Yit* treatment countries

Treated	Coef.	St.Err.	*t* value	*p* value	95% conf. interval	Sig
Constant	0.074	0.018	4.15	0.000	0.039–0.109	***
Mean-dependent var	0.074		SD-dependent var		0.262	
R-squared	0.000		Number of obs		216.000	
F-test	0.000		Prob > *F*		.	
Akaike crit. (AIC)	36.177		Bayesian crit. (BIC)		39.552	

Note: *** represent the level of significance at 1%

significant in determining the attraction of green financing to the economies of the treatment countries. In the same vein, research and development (R&D) is highly significant to attracting green financing to the treatment countries. This variable makes it possible for new knowledge to be discovered that would attract investments from both abroad and home to invest. Technological diffusion through R&D is critical to getting the right investments from multilateral development banks into the sector. The six MDBs cumulatively spent about $237 billion over the last 9 years on climate finance (Tanner and Horn-Phathanothai 2019). More so, a work by Ndlovu and Inglesi-Lotz (2020) found that R&D is a catalyst for technological progress in that it brings to bear new knowledge that ultimately improves energy production process and consumption (Iqbal et al. 2019), (Al Asbahi et al. 2019), and (Sun et al. 2019).

Table 4 shows the $T = 0$ and $T = 1$ effect. Furthermore, they asserted that R&D is a driver of energy transformation system, making room for the modernization of grids and the integration of renewable resources of the energy matrix. However, the correlation is a negative one. On the heels of this understanding, FDI is equally significant in attracting green finance to the energy sector and therefore helps to mitigate climate change effects. It has a direct correlation and perfectly significant. It is suggesting that as FDI increases, green finance increases. The inflow of foreign direct investors (FDI) is a significant factor in scaling up green finance. According to Xie et al. (2020), before 2007, global FDI cumulatively reached $1.9trillion, a chunk of that amount going to emerging countries.

Several studies have concurred to this assertion from the analysis, such as Xie et al. (2020) and Sun et al. (2020a, b, c, d). Zhou et al. (2019) who said the amount of FDI inflows indicated the flow of FDI at the provincial level in China. Xie et al. (2020) confirmed that FDI accentuated CO_2 emission levels in emerging countries. Again, the technical cooperation grant (TCG) as a balance of payment of the treatment countries is significant. Technical cooperation entails any free financial assistance given to increase the technical capacity of a country, without giving specific projects to invest in. In this view, emerging countries need TCG to increase their capacity to invest in green technologies. Indeed one crucial initiative

Table 3 Regression with a dummy variable for treatment controlling for *X*

Treat	Coef.	St.Err.	*t*-value	*p* value	95% conf. interval	Sig
Rescon	− 0.004	0.002	− 2.90	0.004	− 0.007 to − 0.001	***
Gdppercapitapppcon~r	0.000	0.000	− 2.65	0.009	0.000–0.000	***
InflationconsuMerp~l	− 0.013	0.005	− 2.80	0.006	− 0.023− 0.004	***
Rd	0.000	0.000	1.86	0.064	0.000–0.000	*
Tcg	0.000	0.000	3.08	0.002	0.000–0.000	***
Pop	− 0.013	0.002	− 5.96	0.000	− 0.017 to − 0.009	***
Fdi	0.000	0.000	− 1.99	0.048	0.000–0.000	**
CO_2	0.000	0.000	− 2.52	0.013	0.000–0.000	**
Investment in Energy~u	0.000	0.000	0.83	0.406	0.000–0.000	
Hci	0.042	0.185	0.23	0.821	− 0.323–0.406	
Dctopsgdp	0.000	0.000	5.64	0.000	0.000–0.000	***
Constant	1.238	0.150	8.23	0.000	0.941–1.534	***
Mean-dependent var	0.304		SD-dependent var		0.461	
R-squared	0.314		Number of obs		214.000	
F-test	8.424		Prob > *F*		0.000	
Akaike crit. (AIC)	208.030		Bayesian crit. (BIC)		231.592	

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 4 *T* effects *T* = 0 and *T* = 1

	N	Mean	Sd	Min	Max
Rescon	151	26.532	26.732	0	88.832
Gdppercapi~*r*	151	9.33E+11	2.04E+12	2279.531	9.23E+12
Inflationc~*l*	151	7.99	6.418	− 0.704	39.907
Rd	151	− 679.534	4598.194	− 31600	5372.719
Tcg	151	2.31E+08	1.74E+08	0	9.59E+08
Pop	151	64.704	5.441	53.025	73.068
Fdi	151	6.37E+09	9.67E+09	483000000	4.71E+10
CO2	151	1030000	2370000	0	1.03E+07
Investment~*u*	151	1.38E+09	3.63E+09	0	3.45E+10
Hci	149	0.038	0.14	0	0.845
Dctopsgdp	151	63.984	47.499	0	164.664
Treat 1					
Rescon	65	20.205	13.178	0	44.461
Gdppercapi~*r*	65	6.85E+11	1.34E+12	3931.765	3.97E+12
Inflationc~*l*	65	6.667	4.082	0.631	23.115
Rd	65	884.499	3028.878	− 11400	11590.63
Tcg	65	1.96E+08	1.20E+08	0	4.48E+08
Pop	65	56.003	23.396	0.503	70.462
Fdi	65	6.48E+09	6.35E+09	0.503	2.20E+10
CO_2	65	460000	653000	0	1810000
Investment~*u*	65	1.77E+09	2.75E+09	0	1.36E+10
Hci	65	0.046	0.164	0	0.729
Dctopsgdp	65	2.73E+09	6.09E+09	0	3.03E+10

called from “billions to trillions” in official development assistance (ODA) from the World Bank Group seeks to maximize every grant and financing opportunities totaling about $1 trillion geared towards development finance (Baiocchi et al. 2011).

Another covariance that came out significant is the carbon dioxide (CO_2) variable. This was anticipated. The issue of climate change is caused by CO_2 that has made the world look for ways to limit the existential threat to human existence through the formation of the Paris Agreement that seeks to limit global temperatures rising beyond 1.5 °C pre-industrial levels, through the use of market and non-market instruments. It is perfectly significant and has a direct correlation with the green finance variable on the equation. The N-11 countries cumulatively emitted 12.41% of global emissions and generated above 10% of income in 2016 (Sinha et al. 2018). One of the ways to mitigating the CO_2 emission levels is to through emission trading systems (ETS) whereby companies trade for CO_2 allowance and as well as a tax system that taxes the externality caused by the CO_2 emission. Tax is a disincentive because it is a cost and could curb the CO_2 emission rates down (L. Sun, Cao, Alharthi, et al., 2020). However, a study by Shmelev and Speck (2018) found taxes alone not to reduce CO_2 levels in Sweden effectively. The Paris Agreement has equally placed on countries nationally determined contributions (NDCs) to endeavor to limit their CO_2 emission levels voluntarily. A groundbreaking study by Kirezci et al. (2020) paints a glooming picture of the adverse effects of climate change on the world by concluding that at a business as usual approach, about 48% of the world’ s land, more than half of the world’s population, and 46% of global asset risk being flooded. And that 68% of coastal areas will be flooded due to tide and storms and 32% as a result of regional rise in seal level. A Qu essential market-based approach is the China’s emission trading scheme that started off in 2017 and could significantly lower China’s emission levels through its NDCs, as a global number one emitter (China’ s emissions trading scheme 2020).

The analysis equally showed that the population is significant in determining how green financing can flow to N-11 countries. These emerging countries have the most of the world population. As in 2018, the cumulative and nominal GDP was around $6.5 trillion and had about 1.5 billion of the world’s population. Their population is higher than China but almost has the same GDP size of China. This sizeable population has increased energy demand that culminated in total consumption of 11% of global share (No and Padhan 2018). This shows how the spending and consumption power of the N-11 countries. A study on the N-11 countries revealed a long-term equilibrium correlation among the population,

Table 5 Probit regression

				Number of obs = 214
				LR chi^2 (12) = 95.21
				Prob > chi^2 = 0.0000
				Pseudo R^2 = 0.3778
				Log likelihood = − 78.409632
Coef.	Std.Err.	*z*	*P* > *z*	95% conf. interval
0.008	0.007	1.15	0.252	− 0.006–0.023
0.000	0.000	− 3.44	0.001	0.000–0.000
− 0.014	0.017	− 0.81	0.421	− 0.048–0.020
0.000	0.000	− 0.83	0.406	0.000–0.000
0.000	0.000	− 2.16	0.031	0.000–0.000
− 0.045	0.013	− 3.53	0.00	− 0.070 to − 0.02
0.000	0.000	1.91	0.057	0.000–0.000
0.000	0.000	1.56	0.119	0.000–0.000
0.000	0.000	1.2	0.230	0.000–0.000
0.225	0.833	0.27	0.788	− 1.409–1.858
0.000	0.000	0.05	0.963	0.000–0.000
3.835	0.863	4.44	0.000	2.144–5.526

technological progress, and renewable consumption (Sinha et al. 2020).

Finally, the Human Development Index and domestic credit to the private sector were not significant in accessing green financing. Additionally, regression with a dummy variable controlling *X* indicates all the outcome variables, except Human Development, investment in the energy sector by the private sector, are significant in scaling up green finances and climate change mitigation strategies among the treated countries in the study (Baloch et al. 2020) and (Sun et al. 2020a, b, c, d).

Propensity score matching

Table 5 gives a description of the treated and the untreated before the probit regression. The countries that were treated are 155, and the untreated is 61. These were N-11 countries and the BRICs.

Probit regression models give binary outcomes, and so they aptly describe the DID results above. The results indicate that covariates of inflation, GDP per capita, research and development, technical cooperation grants, and population would not likely have any impact on the treated countries regarding green finances and climate change mitigation. On the contrary, investments, CO_2, investment in energy by the private sector, Human Development Index, and domestic credit to the private sector will likely have impact on the treated countries. Renewable energy consumption in final energy consumption as a proxy for green finance will likely have impact on the treated countries' green finance and climate change mitigation strategies.

Table 6 Estimated propensity score

Percentiles (%)	Smallest			
1	0.5199037	0.4521548		
5	0.6042218	0.5199037		
10	0.6431773	0.5414484	Obs	185
25	0.7468897	0.554879	Sum of Wgt	185
95	1	1	Skewness	− 0.4419857
95	1	1	Skewness	− 0.4419857
75	0.9286675	1		
95	1	1	Skewness	− 0.4419857
99	1	1	Kurtosis	2.473895

Xie et al. (2020) found FDI to be directly correlated with economic growth regarding emerging countries and opens a window of opportunities for these countries to access capital, emerging technologies, and knowledge needed for sustainable economic growth. Green bond insurance proceeds devoted to renewables energy and energy efficiency increased from $4.3billion to $97.8 billion between 2010 and 2017 (Tolliver et al. 2020). The analysis confirmed the results obtained during the analysis. In 2017, green bond issuances reached a total of $160 billion, and the number was anticipated to increase to $250 billion by the end of the year. That growth was modest, given the fact that the green bond market is still a nascent industry. Many emerging and developing countries (EMDE) have embraced the idea and putting policies in place to issue bonds in their financial markets (Sustainable banking network 2018; H. Sun, Pofoura, et al., 2020).

From Table 6, the percentiles from the largest group to the smallest are within the 1% mark, giving us better results. Due to the fact, the residual errors are normally distributed; we can confidently rely on the results at 1% for the smaller percentiles and 99% for the largest percentiles, as reported by the models.

Table 7 shows the various matching order for the analysis. The first matching order is the nearest neighbor matching order, with the average treatment effect on the treated value (ATT) of 5.412. The matching order suggests that countries that are exposed to the treatment have a higher propensity to attract green finances and enforce laws to mitigate the effects

Table 7 Matching methods

	ATT	*t*-value
Nearest neighbor matching	5.412	1.036
Kernel matching method	− 5.233	− 1.388
Stratification method	0.158	0.042
Radius matching method	− 3.823	− 0.980

Table 8 Difference in differences estimation

Number of observations in the diff-in-diff: 216

	Before		After		
Control: 0	151		151		
Treated: 0	65		65		
	0		216		
Outcome var.		S. error	t	$P > t$	
Before					
Control		2012.45			
Treated		2012.769			
Diff ($T - C$)	0.319		0.624	0.51	0.61
After					
Control		2012.45			
Treated		2012.769			
Diff ($T - C$)	0.319		0.624	0.51	0.61
Diff-in-diff	0		.	.	.

R-squared: 0.00

*Means and standard errors are estimated by linear regression

**Inference: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

of climate change. That is because the ATT effect is 5.412. The t-value is 1.036, far above 0.005. The nearest neighbor matching order is known to provide estimates of treatment of exposed group effects that is consistent and less susceptible to variability in the estimates. On the other hand, the kernel matching method produced different results, the ATT value of − 5.233. This explains the fact that countries that are exposed to treatment have experienced adverse effects than those do not receive the treatment. The treatment effect on them is − 5.233. Further analysis of the stratification method has an ATT value of 0.158.

Average treatment on the treated effect on Table 7, using the radius matching method, is − 3.823. The ATT effect on the treated countries is negative. This implies countries that are exposed to the treatment have adverse effects on their green finance and climate change mitigation activities. These results were obtained even confirmed after bootstrapping the results. The ATT came as the same, but with the standard errors reduced.

From Table 8, it is apparent that there is no difference between the countries regarding the countries that received the treatment at a different period and the control group of countries. The DID value is 0.000. The p value after the treatment was not significant.

From Fig. 4, the outcome variable interaction shows that there is a significant difference between the N-11 countries and BRICS. The DID and the treated outcome covariates are conspicuous from the BRCIS (Brazil, Russia Federation, China, India, and South Africa) countries by showing two lines from the figure.

Figure 5 gives a positive trajectory of the treated countries. DID is the difference in differences estimator for the treated countries.

Figure 6 box plot of untreated and treated countries. From the box plot, the minimum value for the untreated countries is about 0.3, and the median value is about 8, and the maximum is about 17. On the other hand, the box plot of the treated countries is zero. This suggests the group of countries that received the treatment have no significant difference between them. The control group has so many variations among them regarding green financing and climate change mitigation. The treatment of the countries takes care of varying heterogeneity within the treated group.

Figure 7 shows the untreated and treated trends in each country by period. Most of the countries have significant differences before the treatment period. However, after receiving the treatment, the differences have been reduced to zero. Countries such as South Africa, Vietnam, Russia, and Turkey have wide differences in the treated period and the untreated period. In contrast, Bangladesh, Brazil, and China did not show so much difference between the treated and untreated periods.

Discussion

The N-11 countries were chosen based on the following reasons; one, they are the next emerging and developing economies to dominate the global economy in the twenty-first century. Second, they are seen as the economies to rival the already established ones, in terms of global trade (except Iran, due to sanctions) energy demand and consumption and carbon footprints. However, it must be noted that the BRICs (Brazil, Russia, India, China, and South Africa) countries were included in the study to evaluate the difference in differences between these major groups of economies cumulatively dominating the global economy currently and the next decade to come. Similarly, the BRIC countries have advanced in almost all aspects of economic development. China is a global leader in installed capacity of renewables like hydropower, solar PV, and wind. China had a share of renewables in its energy mix of 14.3% in 2018 and on its way to exceed the 15% target in 2020 and accounted for 33% investment in renewables in 2018 (IRENA 2020) (Meidan 2020). Besides, approximately 40% of green investment needs of China will be allocated to low-carbon technologies, including transport.

Tackling the issue of climate change in emerging and developing economies (EDME) comes with a unique challenge, given the fact that emission reduction is not a short-term priority for most of the developing world. Their per capita emission is very negligible and as well as with low-income levels. In this regard, the countries feel the need to continue emitting to deliver sound economic growth and promote inclusive development to their citizenry. As the environmental Kuznets

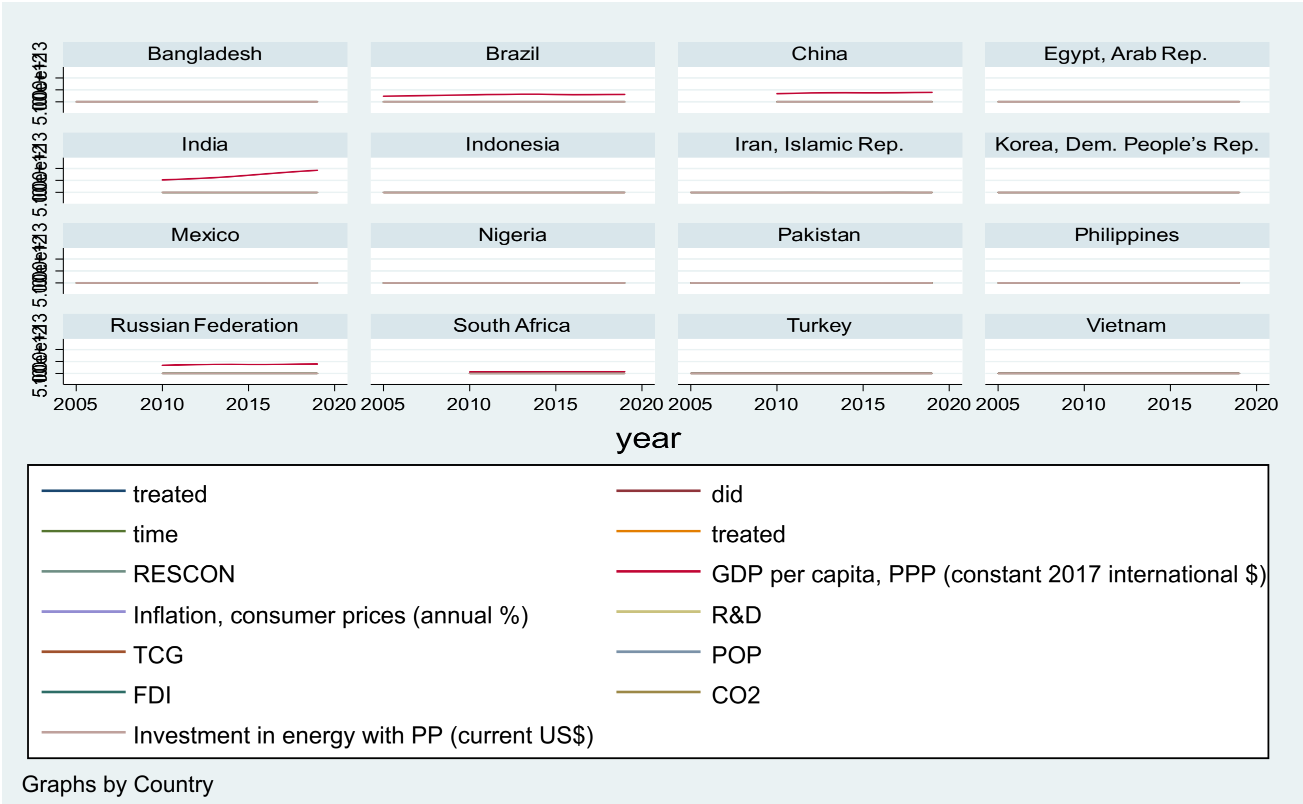


Fig. 4 DID mapping of countries

theory applies, they should pollute and clean later. However, this argument is not tenable because most of these N-11 countries are heavy emitters and the most populous countries in the world. The N-11 countries make up 7.94% of global GDP and emit about 11.2% of global CO_2 emission (Sinha et al. 2018). The issue of burden-sharing demands that the developed world and the developing world alike take proactive steps to avert activities that would increase global temperature beyond the 1.5 °C levels as envisaged by the Paris Accord (Sinha et al. 2020).

However, the remaining 60% will be allocated to water, land remediation, waste treatment, sewerage, etc. between 2014 and 2020 (OECD 2017). South Africa realizing the importance of climate change passed a bill aimed at mitigating the impacts of climate change and transits the country to low-carbon generating technologies and diversifies its energy mix to ensure there is energy security (Government of South Africa 2018). Brazil, as a member country of the BRICS, has jointly launched the "green bonds Brazil 2016" to highlight the importance of working with stakeholders to boost the development of the green bonds market (Kaminker and Majowski 2018). This project was modeled in the same manner as the Global Bond Principles (GBP), which sets out the modalities for promoting transparency and disclosure of green

Fig. 5 Line graph of DID and treated countries

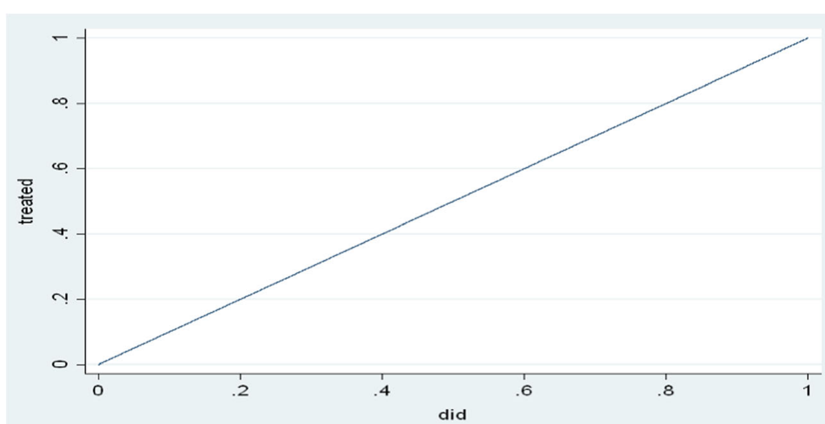
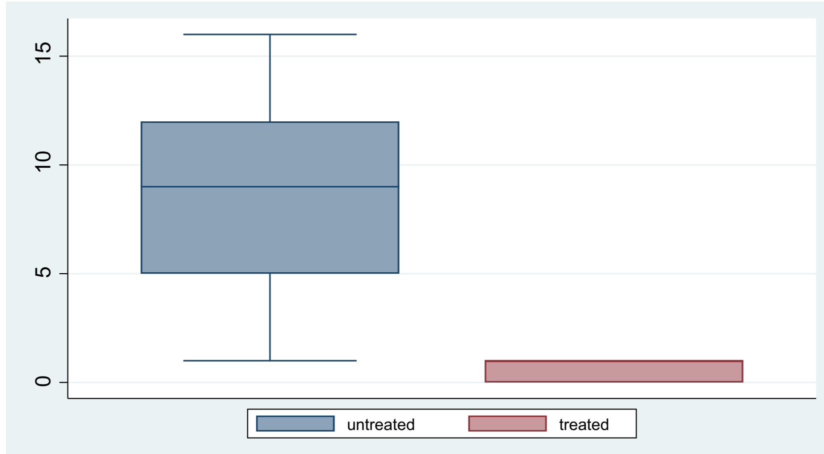


Fig. 6 Treated vs untreated



bonds. Since 2010, more than 50% of $1.3 trillion has been invested in green infrastructure. Bloomberg New Energy Finance (BNEF) estimates that another $14.6 trillion will be needed up to 2040 in investment in clean energy under a 2 °C scenario (Kaminker and Majowski 2018). There has been a geographic shift of renewable investment to emerging and developing countries since 2015, making up 63% of renewable investment in the electricity sector in 2018 (International Renewable Energy Agency 2020). Despite this increase, several EMDE in East-Asia, South-East Asia, and Africa still have huge renewables untapped potential yet to be unexploited that need investment in new technologies and the reinventing of new business models and investment modalities like corporate purchasing of renewables and the emergence of green bond markets to spur on the energy transition (International Renewable Energy Agency 2020).

On the other hand, Mexico, like the rest of the N-11 countries, is taking practical steps to move towards sustainable consumption pathways by reducing environmental degradation and improving energy efficiency programs (Sinha et al. 2018). Furthermore, some of the N-11 countries have advanced in terms of technology and R&D; Korea and Turkey could compete with the BRICS countries like Brazil and Russia in terms of mobile phone usage and other technology.

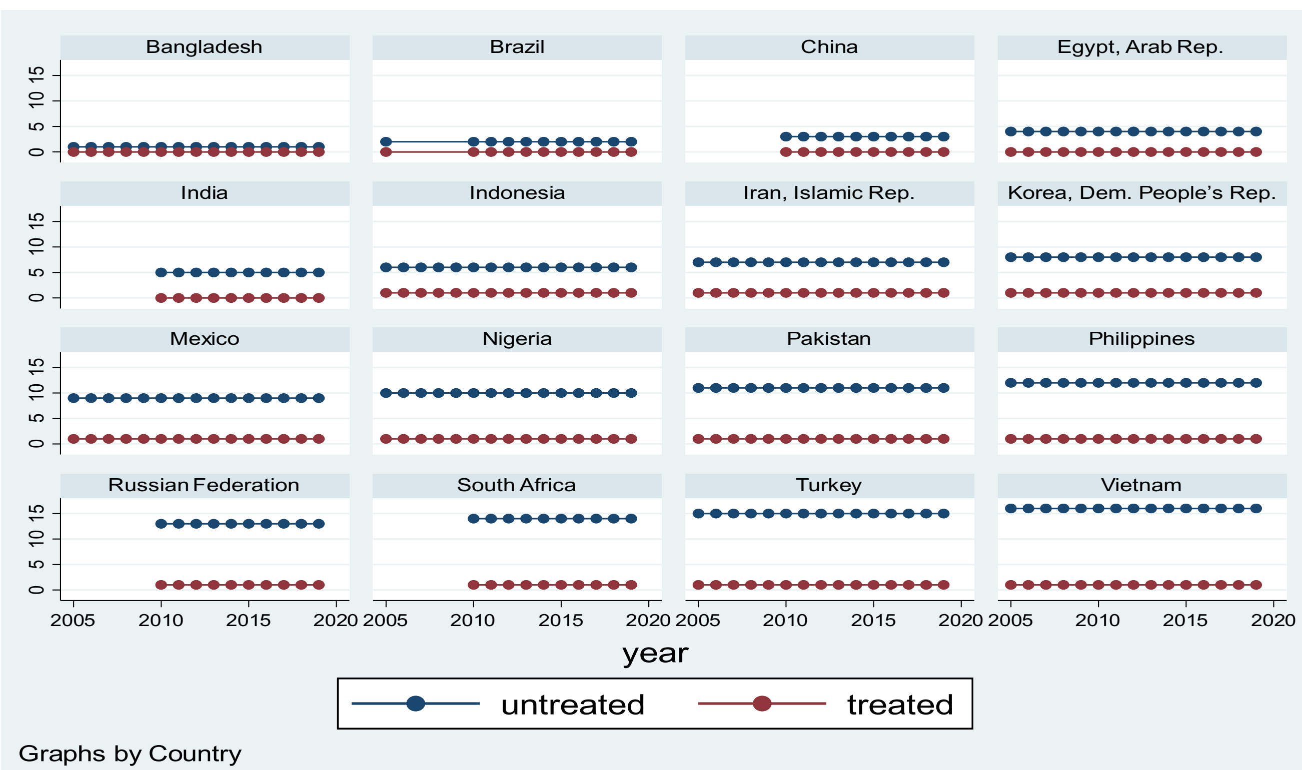


Fig. 7 Untreated and treated matching of the countries

Inversely, the less advanced countries exhibit higher economic growth prospects regarding infrastructure uptake, technology, and R&D (Sinha et al. 2020). Meeting the financial requirements of the sustainable development of goals (SDGs), the world needs to move the target from "billions" to "trillions" in official development assistance (ODA) (Baiocchi et al. 2011). At the heart of this, SDG 7, where sustainable, affordable consumption of energy is central to this goal, about 1$ trillion is needed from all sources to realize the transformative idea of the SDGs. For the N-11 countries to scale up finances in the green projects such as renewables, resilient infrastructures, and sustainable water, there is the need for governments to set up an inclusive financial system that integrates technology (fintech) and multiple financial systems to a country-specific condition, as well as deepen financial capital development by making it easy for countries to enlist and offer green financial instruments. Furthermore, there is a growing awareness in the corporate world, about environmental concerns like emission standards, social and governance (ESG) issues impact on the returns of corporate bodies.

Investment in energy with private participation is another determinant of access to green financing by N-11 countries. It is perfectly significant. Investments in green technologies cannot be made by the public sector alone. Corporate venture capitalists can organize their businesses to invest in a green business on behalf of their parent companies in emerging countries (Röhm et al. 2020). This will boost efforts to creating a public partnership model to catalyze these investments from the private sector. A private and public sector cooperation is needed to unlock the needed funding. Robins et al. (2020) suggested adopting an all-encompassing approach by mobilizing investments across the board to ensure a transition to a green future. America's biggest bank, JP Morgan, has committed about 200 billion dollars into clean financing through to the 2025. The effort is to increase green financing of energy to its institutional and individual clientele across the globe and in the USA (JP Morgan 2018). An essential aspect of this variable is blended finance, which entails concessional funding from development agents, commercial funding from the International finance cooperation (IFC), development institutions, and the private sector. Thus, making room for private sector participation to unlock about $4 trillion investment needed annually to achieve sustainable development goals (SGDs) (OECD 2018).

Conclusion and policy implication

This study analyzed the green financing and climate change mitigation of N-11 countries as well as the BRICS countries, over the period from 2005 to 2019. For us to evaluate whether these countries have any differences in their green financing commitments and climate change strategies between the two time periods, we employed the difference in differences approach by providing a counterfactual hypothesis and then proving it by treating these countries into different periods to ascertain the difference among them. Thus, the control group and the treated group were created among these countries. The presence of unobserved time-varying may cause failure in the assumption. We dealt with this situation by considering pretreatment observables by using matching methods such as the kernel, the radius matching, and the nearest neighbor approach to ascertain the impacts of the treatment of the countries. The act of using matching methods would help balance the likely time-varying perplexing between the treatment and the control group. As Abadie (2018) authority in the DID suggests that, before estimating matching order, it should be done.

The approach has revealed that the need for the N-11 countries and BRICS to formulate policies to address the systemic risks posed by climate change by catalyzing the necessary financing to mitigate these risks and impacts. The analysis showed mixed results depending on the approach as that there is no significance between the N-11 countries and the BRICS countries regarding their green finance and climate risks. The issue of sustainability is very central especially to emerging and developing economies (EMDE).

Moreover, certain factors would underpin these countries accessing green financing and climate change strategies. The GDP per capita of these economies are important to these countries fighting the change risks. The economic performance of any of the N-11 countries is tied to how they can fight climate change and green their macroeconomic policies to mitigate these risks. These risks could come in the form of physical risks to infrastructure and environmental degradation. The probit regression showed CO_2, FDI, RESCON, HDI, and investments in the energy sector have a likely impact on the development of green financing and climate change mitigation strategies on these countries. The need to transition to a low-carbon future has a likely impact on emerging markets formulating and implementing policies to deal with externalities caused by CO_2. Furthermore, FDI is another driver of green financing; the N-11 countries and the BRICS have attracted inflows in the renewables energy sector in particular. Furthermore, countries with good Human Development Index are likely to attract green financing, as it has become a yardstick for these countries receiving green funding either from multilateral development banks (MDBs) or blended finance. Another outcome variable, rescon, which is the proxy for renewables consumption in final energy demand, is a significant variable for the treated countries to attracting green finances. The N-11 countries have some of the most energy intensity ratios, culminating in the emission of CO_2, causing global warming. As a result, some of them have launched programs to transition the economies to a low-carbon future. Indonesia, for instance, has launched the country's low-carbon development initiative (LCDI). Based on the results, it is recommended:

1. The N-11 countries should create a conducive atmosphere to attract foreign direct investment (FDI) to scale up green financing. A standard political risk guarantee is vital in this respect.
2. Governments should support regulations and efforts aimed at developing bond markets.
3. Non-corporates bodies, such as pension funds in emerging and developing countries, should issue green bonds.
4. Finally, green bonds must set up according to the Green Bond Principles (GBP). This will ensure transparency, full disclosure, and the allocation of proceeds for climate attributes projects and assets.

Author contributions Muhammad Atif Nawaz: Conceptualization, data curation, methodology, writing—original draft. Usha Seshadri: data curation, visualization. Pranav Kumar: visualization, supervision, editing. Ramaisa Aqdas: review and editing. Ataul Karim Patwary: writing—review and editing and software. Madiha Riaz: writing—review and editing.

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

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval and consent to participate We declared that we do not have human participants, human data, or human tissue.

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

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