How Renewable Energy Consumption Contribute to Environmental Quality? The Role of Education in OECD Countries

Zafar, Muhammad Wasif and Shahbaz, Muhammad and Sinha, Avik and Sengupta, Tuhin and Qin, Quande

College of Management, Shenzhen University, Shenzhen 518060, China, Beijing Institute of Technology, Beijing 100081, China, Goa Institute of Management, India

1 May 2020

How Renewable Energy Consumption Contribute to Environmental Quality? The Role of Education in OECD Countries

Muhammad Wasif Zafar
College of Management, Shenzhen University, Shenzhen 518060, China
Email: wasif.zafar6@yahoo.com

Muhammad Shahbaz
School of Management and Economics,
Beijing Institute of Technology, Beijing 100081, China
Email: muhdshahbaz77@gmail.com

Avik Sinha
Department of General Management and Economics,
Goa Institute of Management, India
Email: f11aviks@iimidr.ac.in

Tuhin Sengupta
Department of Information Technology & Operations Management,
Goa Institute of Management, India
Email: f13tuhins@iimidr.ac.in

Quande Qin
College of Management, Shenzhen University, Shenzhen 518060, China
Email: qinquande@gmail.com

Abstract: Designing a comprehensive policy framework for ascertaining sustainable development is a problem faced by most of the countries around the globe, and the developed nations are no exception to that. Environmental awareness-oriented policy design for achieving sustainable development goals is a challenge for the developed nations, and there lies the contribution of this study. This study analyzes the impact of renewable energy on carbon emissions, in presence of education, natural resource abundance, foreign direct investment, and economic growth for the Organization for Economic Co-operation and Development countries over the period of 1990-2015. Second generation methodologies are adapted for the empirical estimation. The results show the stimulating role of renewable energy consumption in shaping environmental quality. Education declines carbon emissions. Natural resource abundance and foreign direct investment deteriorate environmental quality. Moreover, the time series individual country analysis also confirms that renewable energy has a positive impact on economic growth. The heterogeneous causality analysis reveals the feedback effect, i.e., bidirectional causal associations among carbon emissions, education, and renewable energy consumption. This empirical evidence suggests that countries should increase investment in education and renewable energy sectors and plan for research and development in renewable energy for ensuring environmental sustainability.

Keywords: Renewable Energy; Education; Economic Growth; OECD

1. Introduction

It is evident that nations are coming together not just to formulate sustainable industrial practices but also to create sustainable living conditions. Among the 17 sustainable development goals (SDGs), tackling climate change has been one of the major challenges from the perspective of policy directive in developed as well as in developing nations (Baumeister, 2018; Bisbis et al., 2018). This is further substantiated by recent research on the alarming levels of carbon emissions predicted for 2020 (Figueres et al., 2018; Quéré et al., 2018). The projections were declared by the "Global Carbon Project" on 5 December, 2018 at the "24th Conference of the Parties to the United Nations Framework Convention on Climate Change" (COP24) in Katowice, Poland. It was interesting to note that not only emerging economies (e.g., India and China), but also developed nations (e.g., the USA) are expected to showcase 2.5 percent rise in emissions, because of high energy consumption. As a result, governments need to revisit their policy strategies to curb the use of fossil fuels. As said by Glen Peters from the Center for International Climate Research in Oslo, "We need more policies focusing on putting fossil fuels away".[1] This provides a strong motivation to revisit energy policy of developed nations from the perspective of climatic shift.

The latter half of the twentieth century witnessed serious public concern regarding the environmental quality, and this includes international frameworks (Millennium Development Goals and SDGs), impact assessment laws and formation of state ecological organizations (Frank et al., 2000; Sharif et al., 2020a). It has been found that rising environmental awareness is one of major successes of these institutions (Constant and Davin, 2018; Sarti and John, 2019). Akerlof (2017) further suggests three conditional factors which can enhance the role of environmental awareness in mitigating issues related to environmental degradation. First, a policy needs to be in

[1] https://www.nature.com/articles/d41586-018-07666-6

place to promote behavioral change among individuals. Second, in order to have fruitful solutions in place, decision making institutions should have democratic participation processes. Finally, there should be a direct focus towards community level changes in education and values.

Environmental education or awareness is a key factor in determining the ecological quality of a nation (Sinha et al., 2019, 2020). There are evidences on rising environmental awareness as an instrument for energy policy both in the academic as well as grey literature (Saifullah et al., 2017; Zhu et al., 2018). Akerlof (2017) addressed this concern on the timing of environmental awareness as a policy tool. The recent report published by OECD (2019) shows the position of the OECD nations in terms of their attainment of the SDGs, and it might be said that, one of the major reasons behind this shortfall is the lack of research-based innovations and initiatives. The persisting distance in case of the attainment of SDG 8 (clean and affordable energy) and SDG 13 (climate action) gives an indication about the low penetration of renewable energy solutions across the nations (OECD, 2019). Low penetration in research and development activities can be attributed to poor educational attainment, and this might have negative impact on the environmental quality in two ways, i.e. by restricting the ways to the discovery of renewable energy solutions, and restricting the diffusion of environmental awareness among the citizens (Hess and Collins, 2018). Therefore, educational attainment might have an environmental impact, which can be realized in the renewable energy generation. There lies the focus of the present study.

In accordance with Grossman and Krueger (1991), environmental awareness arising out of education forces the policymakers to formulate environment-friendly policies, which causes the Environmental Kuznets Curve (EKC) to take an inverted U-shaped form. Therefore, it can be said that education plays a significant part in reducing the deterioration of ecological quality, and henceforth, role of education in achieving the objectives of SDGs can prove to be crucial. Therefore, impact of education, economic growth, and use of green energy are considered as major determinants of climate change. It can also be argued that foreign direct investment (FDI) is a potential mean to attract clean energy technologies and/or promote significant economic activities in any region. This is necessary to the already existing organic mode of development in the region. Therefore, FDI is considered as one of factors that could impact climate change in the region (Eastin, 2018). Also, natural resource abundance also highlights the importance of natural resource consumption in catalyzing the issue of climate change (Roy and Singh, 2017). The role of natural resources can prove to be important from the perspective of sustainable development, as following "Limits to Growth" approach, continuous reliance on natural resources for achieving economic growth might cause harm to the economic growth itself (Meadows, 1974). Therefore, for achieving the objective of SDG 8 (decent work and economic growth) and SDG 13 (climate action), reliance on natural resources needs to be reduced.

In this study, this association is analyzed for 27 OECD countries over a period of 1990-2015. This is motivated by the fact that most of the developed nations belong to the OECD member category and would serve as a proper framework to investigate whether the developed nations are progressing in the current path or not with respect to optimal strategy to climate change mitigation. In doing so, these nations should rely more on their educational attainment for enhancing environmental awareness, so that it can catalyze the renewable energy implementation in these nations. The present study attempts to develop a SDG framework by redesigning the existing energy and environmental policies in the OECD countries, so that the issues pertaining to SDG 13 and SDG 7 can be addressed. This policy framework is aimed to be designed by considering the impact of education in shaping the renewable energy-climate change association. There lies the policy level contribution of this study.

The remainder of the paper is as follows: A brief literature review on the existing literature concerning OECD nations is presented in the subsequent section. Section-3 explains the data and modeling structure relevant for our study. Section-4 discusses the methodological structure of the paper. Section-5 and Section-6 presents the findings and policy implications of our paper, respectively. Section 7 concludes the paper.

2. Literature Review

Within the developed world, the OECD nations form an important part of the world economy and were one of the first to initiate and investigate climate change mitigation strategies to the United Nations (OECD, 2017, 2019). Developed nations should have been the pioneers for sustainable development as they can invest in cleaner technologies for achieving economic growth. Unfortunately, the recent report on carbon emissions suggests that OECD nations too have rising level of emissions (OECD, 2019). This is in strong contrast to the argument that typically developed nations should have better literacy rate, leading to superior environmental awareness among the population (Emiru and Waktola, 2018). In addition, literature suggests that it will be in the interest of policymakers to design clean energy and environment friendly policies in OECD countries to combat climate change. For instance, Polzin et al. (2015) examined the role of public policy measures on renewable energy consumption and investment. Their results highlight the need for technology specific policies. In additions, policy directive highlights the need for institutional investments in renewable energy segments and therefore urges OECD nations to promote fiscal incentives for such investors. However, it needs to be seen how economic growth and climate change are influenced with such policy directives. Taking a cue from this discussion, this section will briefly review the studies on the association between environmental quality, economic growth, energy consumption, FDI, natural resource and renewable energy sources.

Jebli et al. (2016) studied the association among CO_2 emissions, international trade, income growth, and energy consumption from disaggregated sources. In addition to the verification of EKC hypothesis, the results indicate that improved international trade and increased use renewable energy solutions are important strategies to combat climate change. This is logical because developed countries would indulge cleaner technologies in international trade and thereby, in the long run, reduce carbon emissions. A long-run bidirectional causal relationship was reported among the considered variables. Shafiei and Salim (2014) explored the determinants of carbon emissions using the stochastic impact by regression on population, affluence, and technology (STIRPAT) model for OECD countries between 1980-2011. Their results show that consumption of non-renewable energy increases carbon emissions and renewable enrgy consumption decreases energy consumption. Also, the study supports the existence of EKC hypothesis between urbanization and environmental degradation. Therefore, the overall policy directive was to promote urban develoment and the use of renewable energy source for combating climate change. Zhu et al. (2016) studied the impact of FDI, energy consumption, and economic growth on carbon emissions in ASEAN-5 countries. Using a panel quantile regression, the study found that FDI can reduce carbon emissions. Further, it was found that economic growth exerts adverse effect on environmental quality in high emission countries. Impact of different independent variables on emissions were found to be heterogenous arcoss the quantiles. Lee (2013) on the other hand found no correlation between FDI inflows and carbon emissions in G20 countries. However, carbon emissions and economic growth were found to be negatively correlated during the period of 1971-2009. As G20 countries are already developed countries, it can be argued that further FDI into these countries might not promote clean energy technologies. For BRIC nations, Pao and Tsai (2011) found that FDI and carbon emissions are positively correlated, thereby suggesting that emerging nations need to carefully scrutinize the stipulations for FDIs or impose ecological fortification guidelines for such transactions. Studies of similar nature have reported divergent results for single country studies (Sinha and Shahbaz, 2018) as well as for multi-country studies (Behera and Dash, 2017; Shahbaz et al. 2019).

With regard to the environmental education and awarness, there has been lot of studies highlighting the importance and relevance of the topic to the modern world (Sánchez-Llorens et al., 2019; Faize and Akhtar, 2020). For instance, there are studies concerning education and biodiversity conservation (Ramírez and Santana, 2019), environmental education and climate change disaster risk management (Chirisa and Matamanda, 2019; Ketlhoilwe, 2019), etc. However, there are very few studies to the best of our knnowledge which directly links environmental education with mitigation of carbon emissions (Almeida et al., 2018). This provides an opportunity to delve deeper into the linkages of environmental education and consciousness and sustainable development (Pashollari, 2019; Stevenson, 2019) espeically in OECD countries where the level of education and awareness is assumed to be higher.

To summarize, literature has highlighted the positive benefits of renewable energy consumption to OECD economic growth, whereas results also contradict this claim and reinstate the need to focus on non-renewable energy source to support industrial output. Further, literature considers public policy measures to be extremely important for promoting utilization of green energy in OECD countries (Pan et al., 2019). However, from the perspective of SDGs, it is imperative to understand why developed nations are unable to combat climate change, despite environmental awareness among people. This is important to suggest signals to emerging and frontier markets and promote a gradual shift towards sustainable policies. The present study adds to this discourse by reassessing the sustainable development policies in OECD countries by incorproationg environmental awareness in policy decisions, and comments on the sustainable development trajectory of these countries.

3. Empirical model

3.1. Theoretical background

Prior to start with the empirical schema, preparation of the theoretical background is necessary, based on which model variables will be chosen. The OECD countries are considered under the group of developed nations, and these nations are characterized by high economic growth, which is catalyzed by continuous energy consumption. Now, with graduation of time, these nations have shifted from fossil fuel-based energy consumption to renewable energy consumption or green energy consumption, in order to sustain their economic growth pattern. These nations have also experienced an uprising in terms of cleaner production processes, which entails utilization of green energy. Consequently, the utilization of green energy will not only encourage the nation-wide diffusion of cleaner production processes, but also will have a positive impact on environmental quality by reducing CO_2 emissions. Subsequent to the diffusion of cleaner production technologies across the nations, several job creations might take place, and in this way, the nations will be able to recover the cost incurred in course of the implementation of renewable energy solutions.

Further, it needs to be stated that the OECD nations are also rich in terms of natural resources, and pace of industrialization in these nations might not sustain based on only renewable (green) energy consumption pattern. Therefore, these nations might resort to their pool of natural resources for fulfilling their energy demand (Mantovani et al., 2017; Zafar et al., 2019). Most of these natural resources have molecular hydrocarbon structure, and during the course of consumption, these hydrocarbons are oxidized, and thereby, generates CO_2 emissions (Pauli, 1997). In doing so, environmental quality deteriorates with the abundance of natural resources and the growth trajectory. This might be a consequence of poorly defined public property rights. Along with this, most of these countries are still relying on the environmentally harmful technologies, which they have acquired via technology trade (Barber, 2007). The rent from these technologies are received at the cost of environmental quality, and existing trade policies of these nations towards mobilizing foreign direct investment (FDIs) can be held responsible for this situation (Lozano et al., 2018; Morin et al., 2018).

Here the role of education in reducing the environmental degradation should be discussed. After growth in income reaches a brink, environmental degradation comes down owing to rise in environmental awareness. This is not an automatic process, and this rise in environmental awareness is generated by rise in the level of education among the citizens, and by education, they can assess their ecological surroundings. When they feel the sustainability of this economic growth might be at stake, they demand environmental protection, through legal enforcement and awareness. This entire movement is possible due to education. In this regard, the role of people-public-private partnerships should be recognized for creating environmental awareness among the citizens. Now, in order to enable this partnership, education system has to corroborate to the motives of ecological sustainability. Hence, not only education should be improved, but also the lessons of environmental awareness should also be included in the high school curriculum, so that citizens and budding workforce of these nations can have a basic idea about energy efficiency and environmental protection. In this way, environmental quality can be improved via education system.

Succinctly, when FDI and natural resources exert scale effect on environmental quality, renewable energy consumption exerts the composition technical effect, whereas the technique effect is exerted by education, which helps in building the capacity for environmental protection. Hence, it can be argued that utilization of renewable energy and education are anticipated to exert adverse impact on CO_2 emissions, whereas FDI, natural resources abundance, and economic growth might exert affirmative impact on CO_2 emissions. Figure-1 outlines the empirical schema.

<Insert Figure 1 here>

3.2. Modeling and Data

In order to examine the impact of education (EDU), per capita foreign direct investment (FDI), per capita natural resources abundance (NR), and per capita renewable energy consumption (RNE) on per capita CO_2 emissions (CO_2), by incorporating economic growth (GDP) as the control variable in the theoretical framework, following econometric model is used:

$$CO_2 = f(EDU, FDI, GDP, NR, RNE) \quad (1)$$

For the purpose of empirical estimation, the model variables are log-transformed, so that the sharpness in data is diminished and variables show better distributional properties. Natural logarithmic transformation helps to remove autocorrelation and heteroskedasticity issues from data. Compared to the linear transformation, results derived from log-transformed models are more consistent and efficient (Hakimi and Hamdi, 2016). The log-transformed version of the empirical model is as per the following:

$$\ln CO_{2,it} = \alpha_{it} + \beta_1 \ln EDU_{it} + \beta_2 \ln FDI_{it} + \beta_3 \ln GDP_{it} + \beta_4 \ln NR_{it} + \beta_5 \ln RNE_{it} + \epsilon_{it} \quad (2)$$

Here, *i* represents the cross-sections (1, … 27), *t* represents the time series (1990, …, 2015), β_i represent the respective elasticities of *EDU*, *FDI*, *GDP*, *NR*, and *RNE*, and ε represents the error term.

Now, while analyzing the impacts of education, natural resources, FDI and renewable energy consumption on CO_2 emissions, it is necessary conducting the analysis following Environmental Kuznets Curve (EKC) hypothesis, so that we can analyze how different factors can exert scale, technique, and composition effects on environmental quality (Sinha et al., 2017). Extending the specification of Panayotou (1993), we have tried to analyze the impacts of the explanatory variables using the quadratic specification of EKC. The impacts of explanatory variables are elucidated in Figure-1 of linear model butthe impacts of quadratic model are expected to be different. Under the EKC framework, except green energy consumption, growth in all the other explanatory variables, i.e. education, real GDP, FDI, and natural resources, is excpected to deteriorate environmental quality, and after attaining a threshold level, further growth in these variables is expected to bring forth improvement in environmental quality. During the initial phases of development, economic growth is the primary concern of nations, and in order to achieve that, environmental protection takes a backseat. This is the period, when the government tries to attract FDI and exploit natural resources, e.g. fossil fuel and forest reserves, and in doing so, vocational opportunities rise. This might be explained in terms of the scale effect of FDI on environmental quality. During this period, rise in the vocational opportunities also leads to rise in education, and this is when the rise in education is also given a higher priority compared to environmental protection. Therefore isolated policy design on education leads to deterioration of environmental quality, and this can be explained by scale effect of education on ecological condition. In such a situation, the existing and rise in the pool of natural resources is more likely to be consumed in pursuit of the rapid industrialization, and therefore, it might cause rise in environmental degradation. This might be explicated in terms of the scale effect of natural resources abundance exerted on the environmental quality. Now, when the income reaches a threshold level, where education generates an enviornmental and social awareness among citizens. The transformation of education to awareness can be considered as the shift from scale effect to technique effect of education on environmental quality, and mathematically it can be explained by the squared term of education. During this period, rise in education or level of awareness leads to improvement of environmnetal quality. This is the phase, when further growth in FDI starts to have lower impact on environmental quality, and natural resources start rising. This phenomenon is explained by the squared term of FDI, which denotes the technique effect of FDI on environmental quality. At the same time, rise in the ecological awareness leads to rise and preservation of natural resources, and the production technologies gradually start turining out to be cleaner and environment-friendly. Therefore, further rise in the natural resources abundance leads to lowering of the environmental degradation. This phenomenon is explained by the squared term of natural resources, which denotes the exertion of technique effect of natural resources on environmental quality. Given the background of implementation of SDG objectives in developed nations, these associations need to be analyzed following an EKC framework. The quadratic EKC model is given by as per the following:

$$\ln CO_{2,it} = \alpha_{it} + \beta_1 \ln EDU_{it} + \beta_2 \ln EDU_{it}^2 + \beta_3 \ln FDI_{it} + \beta_4 \ln FDI_{it}^2 + \beta_5 \ln GDP_{it} + \beta_6 \ln GDP_{it}^2 + \beta_7 \ln NR_{it} + \beta_8 \ln NR_{it}^2 + \beta_9 \ln RNE_{it} + \epsilon_{it} \quad (3)$$

This study is to investigate the impact of education, FDI, natural resources, and renewable energy consumption, on environment quality for OECD countries over the period of

1990-2015. The study has considered the following OECD member countries: Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, South Korea, Luxembourg, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and United States of America. Carbon emissions (CO_2) are measured in metric ton, FDI, gross domestic product measure (GDP), and natural resources (NR) abundance is quantified in constant 2010 US dollar, renewable energy consumption (RNE) is quantified in billion kilo Watt Hour (kWH). Education (EDU) can be estimated by numerous means, such as, number of year that population of 25 year old and over has attend the school (Hill and Magnani, 2002), secondary school enrollment ratio (Gangadharan and Valenzuela 2001, Bano et al. 2018), population that has enrolled in school (Managi and Jena, 2008), and number of enrolled student in graduate and post graduate (Balaguer and Cantavella, 2018). Out of these indicators of education, this study uses secondary education enrollment gross as a suitable proxy for education (EDU), as it requires at least high school level education to understand the issue of environmental degradation and take necessary action. Each variable is converted into per capita unit by dividing with population. The World Development Indicators (World Bank, 2018) is used to collect the data for carbon emissions, FDI, GDP, secondary school enrollment, and natural resource abundance. Renewable energy consumption data is obtained from The US International Energy Agency database (IEA, 2017).

4. Procedural Outline

4.1. Cross-sectional Dependence Test

The examination of cross-sectional dependence (CD) in the panel data is of utmost importance, as presence of the same might produce biased and inconsistent results (Phillips and Sul, 2003). In reality, countries are connected with each other via different channels, e.g., economic, social, political, bilateral trade, and board sharing. These forms of associatively among the countries might result in CD among the model variables. To address the same, we use CD test by Pesaran (2004), and Lagrange Multiplier (LM) test as suggested by Breusch and Pagan (1980). The following equation is used by CD test to examine the presence of CD in the data.

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=0}^{N-1}\sum_{j=i+1}^{N}\rho_{ij}\right) \tag{4}$$

Where, N denotes the cross-sections, T characterizes the period. The heterogeneous correlation of stochastic variations is explained as ρ_{ij}. LM test utilizes the following equation to examine the CD in the panel data.

$$y_{it} = \alpha_{it} + \beta_i x_{it} + \varepsilon_{it} \tag{5}$$

Where, i denotes the cross-sections, t characterizes the period. Both these estimation techniques assume absence of cross-sectional dependence as null hypothesis, whereas alternative hypothesis explains the presence of CD in the panel data.

4.2. Cross-Sectional Unit Root Test

In the presence of cross-sectional dependence, first generation unit root tests are ineffective due to low power in accommodating cross-sectional dependence. Moreover, these tests assume no cross-sectional dependence. This issue is solved by using cross-sectional Im-Pesaran-Shin (CIPS) and cross-sectionally augmented Dickey-Fuller (CADF) introduced by Pesaran (2007) in the presence of cross-sectional independence. These both tests consider cross-sectional and heterogeneity across panel. In the literature, various studies have used second generation unit tests to examine the stationary properties of the variables. It can be defined as the following:

$$\Delta x_{it} = \alpha_{it} + \beta_i x_{it-1} + \rho_i T + \sum_{j=0}^{n} \theta_{it} \Delta x_{i,t-j} + \varepsilon_{it} \tag{6}$$

Where, x_{it} explains the considered variable, i denotes the cross-sections, t characterizes the period, ε_{it} explains the residuals of the model. The null hypothesis considers non-stationarity, against alternative hypothesis of stationarity.

4.3. Westerlund Cointegration Test

Once the order of integration of the model variables is found, the subsequent phase will be to examine the cointegration association among the model variables. Following the aforementioned unit root test outcome, the use of first generation cointegration methodology may produce biased results due to inability to accommodate cross-sectional while determining the long-run cointegrating association among the model variables. Therefore, we use the Westerlund (2008) cointegration test, which is based on Durbin-Hausman (DH) principle, to examine the long-run relationship among the variables. Westerlund cointegration test suggests two statistics, DH-panel and DH-group statistics, and DH principle uses common factor to consider cross-sectional. The other advantage in using these tests is that they are robust against the presence of stationary regressors (Westerlund, 2008).

According to Auteri and Constantini (2005), these tests also accommodate the cross-section dependence with the help of factor modeling. In the factor modeling, residuals are obtained through the unobservable factors (which are similar across the panel units) and idiosyncratic innovations. Thus, factor models of residuals are presented below:

$$\varepsilon_{it} = \lambda_i^{/} F_t + e_{it} \tag{7}$$

$$F_{jt} = \rho_j + F_{j(t-1)} + \mu_{jt} \tag{8}$$

$$e_{it} = \varphi_i + \varphi_{i(t-1)} + \eta_{it} \tag{9}$$

Where F_t represents common factors whereas F_{jt} represents vector of factor loadings subject to confirmation. The stationarity of F_t is ensured here by assuming $\rho_j < 1$ is less than all j in the models. In our case, regression residual ε_{it} is only based on integration of idiosyncratic disturbance e_{it}. Therefore, first we test the null hypothesis which represents no cointegration by satisfying that $\varphi_i = 1$ in the equation. We used two panel cointegration tests which are panel test and the other one group mean test. Through the panel test we check whether $\varphi_i = \varphi$ by following the maintained assumption. In the same way, group mean is constructed for all i, by following the maintained assumption that $\varphi_i \neq \varphi$. Both the tests (panel and group mean) bearing estimators of φ_i possess different probability boundaries towards alternative hypothesis but share the consistency property for null hypothesis of no cointegration. We can use OLS estimators and instrumental variables to get Durbin-Hausman (DH) tests. Thus, we can formulate following equations to obtain DH_g and DH_p tests:

$$DH_g = \sum_{i=1}^{N} \hat{s}_i (\varphi_{1i} - \varphi_{2i})^2 \sum_{t=2}^{T} \hat{e}_i^2 (t-1) \tag{10}$$

$$DH_P = \hat{S}_n (\varphi_1 - \varphi_2)^2 \sum_{i=1}^{N} \sum_{t=2}^{T} \hat{e}_{i(t-1)}^2 \tag{11}$$

Where φ_1 denotes OLS estimator of φ_i, whereas φ_2 represents pooled mean estimator. By Instrumenting $\hat{e}_{it}$ with $\hat{e}_i(t-1)$, it gives corresponding pooled estimator of $\varphi_i$denoted by φ_{1i} and φ_1 , respectively. The null and alternate hypothesis of panel test are created as H1p: $\phi_i = \phi$ and $\phi < 1$ for all i against H0: $\phi_i = 1$ for all i = 1…. N. Under the alternative and the null hypothesis a common autoregressive parameter is assumed. On the contrary, to test DH_g, H0 is measured against alternative hypothesis shown as $H1_g = \phi_i < 1$ not for all but atleast for some i. For this situation, heterogeneous autoregressive parameters are expected crosswise over panel units. Hence, rejection of the null hypothesis, in this case, shows absence of long-run relationship for some of the panel units.

4.4. Estimation of Long-Run Elasticities

While estimating the long-run elasticities of the model variables, cross-section should be taken into consideration. In order to address this issue, this study uses "continuously updated fully modified (Cup-FM)" and "continuously updated bias corrected (Cup-BC)" estimation methods to determine the long-run elasticities of the variables. These tests were introduced by Bai et al. (2009). These methods estimate the slope parameters which include the unobserved common trends jointly following an iterated procedure. It allows for cross-sectional dependence and endogeneity. Moreover, these estimation methods are robust to mixed I(1)/I(0) factors and regressors. The Cup-FM estimation assumes the error term follows a factor model. Further, the parameters and loadings are computed recurrently till conjunction. Thus, we can formulate it as follows:

$$(\hat{\beta}_{CUP}, \hat{F}_{CUP}) = \arg\min \frac{1}{nT^2} \sum_{i=1}^{n} (y_i - x_i\beta)' M_F (y_i - x_i\beta) \tag{12}$$

Where, $M_F = I_T - T^{-2}FF'$, I_T and F shows the identity matrix of dimension T, and the covert joint factors are undertaken within error term. Therefore, the preliminary estimates are apportioned to F, and it carried on up to conjunction.

Along with this, pooled mean group (PMG) estimator based autoregressive distributed lag (ARDL) model (Pesaran et al., 1999) is used for robustness checking. The PMG estimation takes the average and pools the coefficients across the panel. In this technique, a restriction is imposed on long-run parameters, and thereby, long-run effects remain homogeneous and short-run effects can vary across the panel.

5. Analysis and discussion of results

For proceeding with analysis, it is necessary to check the possibility of multicolinearity in the data, as it might result in erroneous outcome. We have checked the correlation among the variables, and the outcome reported in Appendix 1 gives an indication about the possibility of multicolinearity among the model parameters. For ascertaining this aspect, the variance inflation factors (VIFs) for all the model parameters have been computed, and the test outcome gave an indication regarding the presence of multicolinearity among the model parameters. In order to tackle this issue, the model parameters have been orthogonally transformed, and further checking of VIFs for all the model parameters reveals that the multicolinearity issue has been resolved. The test outcome has been reported in Appendix 2. With this evidence, the empirical estimation can be started.

The empirical estimation is started with checking the presence of cross-sectional dependence in the model. The results from cross-sectional dependence and LM tests are presented in Table-1. The null hypotheses of both the tests are rejected, and thereby confirming the existence of cross-sectional dependence. The presence of cross-sectional dependence endorsed to use second generation unit root tests for examining the integration properties of variables. For this purpose, CADF and CIPS unit roots are used, and results of both the tests are presented in Table-2. CIPS test results indicate that the model variables have unit root at level, but stationary at first difference. The presence of unit root at level and stationary at first difference is indicated by CADF unit root.

Once the nature of stationarity for all the variables is determined, cointegrating linkage between the variables needs to be assessed. For this purpose, Westerlund (2008) cointegration test has been employed, and the test outcomes are showed in Table-3. The results imply the presence of cointegration among the model parameters in the OECD region for the period of 1990-2015.

Subsequent to this stage, the long-run elasticities of the explanatory variables with respect to CO_2 emissions are estimated. For this, linear and quadratic EKC models using Cup-FM, Cup-BC, and PMG estimation procedures are estimated, and the results are reported at Table-4 and 5. First, the linear model is analyzed. All the three tests show that education has a negative impact on CO_2 emissions. The rising education helps in increasing environmental awareness among the citizens, which in turn catalyzes the reduction in emissions either by encouraging public protest or by enabling them to build people-public-private-partnerships to bring forth clean production processes. Puukka (2008) has identified the role of education in shaping sustainable development for the case of OECD countries, and this broadly substantiates our finding. This finding is complemented by Bano et al. (2018), who concluded that education significantly improves environment quality. Now, these changes in the production processes have resulted in the introduction of renewable (green) energy solutions in the economy, and then it will have a direct positive impact on environmental quality. Empirical results are consistent with the findings of Danish et al. (2017) for Pakistan and Sinha and Shahbaz (2018) for India. This change is catalyzed by both government regulations and growing concerns about environmental degradation among the citizens. Moreover, the national target of achieving the objectives of sustainable development goals (SDGs) has compelled the policymakers to undertake the implementation of renewable energy solutions, which has helped in reducing CO_2 emissions. This initiative was necessary, as the economic growth pattern in these countries has affected environmental quality adversely. Jebli et al. (2016) identified the role of renewable energy consumption in improving environmental quality in OECD countries, and this study substantiates our finding. This finding is consistent with Shahbaz et al. (2015) for high-middle- and low-income countries, and Bano et al. (2018) for Pakistan. Moreover, the abundance of natural resources might also compel these nations to utilize them as the enabler of economic growth, and thereby, this abundance in natural resources can affect environmental quality adversely, as fossil fuel is one of the predominant natural resources. Jebli et al. (2016) identified the role of fossil fuel energy consumption in deteriorating environmental quality in OECD countries, and this study substantiates our finding. This segment of the outcome opposes the findings of Balsalobre-Lorente et al. (2018) for 5 European countries and Khan et al. (2016) for Pakistan. This rise in economic growth in these nations has been fueled by the rise in industrialization, which is majorly driven by FDI. Therefore, FDI also has a negative impact on environmental quality. Pazienza (2015) has identified the simlar impact of FDI for transport sector on environmental quality for OECD countries. Findings on the similar line was noticed by He (2006) for China, Sbia et al. (2014) for the UAE, Sapkota and Bastola (2017) for 14 Latin America countries, and Solarin et al. (2017) for Ghana. Owing to these reasons, policymakers in these nations need to control these issues within the broad framework of SDGs, as continuation of these activities might prove to be harmful for sustainable development. Presently, OECD countries are planning to collaborate with World Water Council, United Nations Development Programme (UNDP), other member countries and development partners to ensure sustainability of environment via inclusive growth approach and encouraging partnerships (OECD, 2017). The obtained results and the possible policy directives might help these nations in shaping their plans to achieve SDG objectives.

Now, the quadratic model will be analyzed. The coefficients of education and square of education are positive and negative, respectively, and thereby confirming inverted U-shaped educational Kuznets curve for the case of OECD countries. With the rise in education, the vocational opportunities rise, and thereby, the rise in demand of energy catalyzes the industry to depend on fossil fuel consumption. However, with the higher stages of economic development, education rises, along with the rise in environmental awareness. Owing to this reason, the demand of cleaner energy solutions rises, and thereby, fossil fuel consumption and consequent CO_2 emissions start coming down. This impact of education on CO_2 emissions shows the progress of these nations towards sustainable development. The results complement the findings of Balaguer and Cantavella (2018), who found similar evidence for Australia. However, this result contradicts the finding of Jiang (2015), who did not find any inverted U-shaped relationship between education and CO_2 emissions for Chinese provinces. The reported coefficients of FDI and square of FDI are negative and positive, respectively, and thereby confirming a U-shaped association between FDI and CO_2 emissions, and thereby, refuting the EKC hypothesis. The results indicate that the nature of foreign direct investment in these nations catalyze CO_2 emissions by virtue of rapid industrialization, which also resulted in rapid deforestation and increase in fossil fuel consumption. Therefore, at the earliest stages of growth, nature of FDI affects environmental quality in a constructive manner, whereas at the later stages of growth, FDI results in deterioration of environmental quality. Results of this study complement the finding of Shahbaz et al. (2018) for France and contradict the finding of Bao et al. (2008) for China.

The association between carbon emissions and economic growth resembles an inverted-U shaped form, which validates the EKC hypothesis for OECD countries. These results exhibit that at the outset, economic growth vitiates environmental quality, and after reaching a brink, emissions decrease with an increase in economic growth. This is catalyzed by the rise in the application of cleaner energy solutions, by substituting the prevailing fossil fuel energy solutions being used in production processes. Moreover, with rise in the level of income, education and environmental awareness also rises among the citizens, and this catalyzes the initiation of people-public-private partnerships towards the cross-border diffusion of cleaner technology solutions. In this way, economic growth pattern in these nations indicates the movement towards the achievement of SDGs. The similar results are found Sapkota and Bastola (2017) for 14 Latin America countries, Balaguer and Cantavella (2018) for Australia, and Sinha and Shahbaz (2018) for India. Shahbaz and Sinha (2019) have provided a detailed review on this association. Now, the impact of natural resource abundance on CO_2 emissions will be assessed. The influence of natural resources on CO_2 emissions is positive, while square of natural resources bears negative relation with CO_2 emissions. This finding suggests that initially natural resource abundance increases CO_2 emissions. However, once natural resources abundance reaches at a certain point then carbon emissions will decrease with the increase in natural resources abundance. Rise in natural resources can both constructively and destructively affect environmental quality, subject to the usage of that resource. When natural resource abundance rises, industries try to use natural resources to fuel growth in industrialization, and this is when CO_2 emissions rise with rise in natural resources abundance. However, with rise in economic growth and environmental awareness, the use of natural resources as the fuel in production process comes down, and subsequently, the use of natural resources become sustainable. This is when the rise in natural resources abundance leads to decrease in CO_2 emissions, as the rise in forest cover will also help in absorbing the excess CO_2 emissions in the ambient atmosphere. Lastly, the test outcome implies that energy consumption from renewable sources increase environment quality in OECD countries by reducing CO_2 emissions. This result is consistent with Balsalobre-Lorente et al.

(2018) for 5 European countries and Sinha and Shahbaz (2018) for India. However, this result contradicts the findings of Apergis et al. (2010) for 19 developing and developed countries, and Farhani and Shahbaz (2014) for MENA countries.

Present empirical study further aims to examine long-run carbon emissions elasticities for each individual country included in OECD group. Time series analysis can useful to understand the effects of education, FDI, economic growth, natural resources, and renewable energy consumption on CO_2 emissions across the panel countries. This study uses fully modified ordinary least square (FMOLS) method for time series analysis and results are reported in Table-7. The results reveal that education has negative and statistically significant impact on CO_2 emissions in countries such as: Austria (-1.39), Belgium (-0.06), Canada (-0.77) Finland (-0.48), Greece (-0.81), Italy (-1.34), Luxembourg (-1.91), Spain (-1.26), Sweden (-0.07), Switzerland (-0.07), and Turkey (-0.20). In these countries, as people become more educated, the demand for and adoption of cleaner production technology may increase, thus reducing pollution emissions. On the contrary, education has a positive and significant impact on CO_2emissions in Korea (0.57) and Mexico (0.48). In these countries, economic growth is accomplished by deteriorating environmental quality, and therefore, rise in education comes with greater access to vocational opportunities, which are majorly driven by polluted technologies (Hill and Magnani, 2002). Moving on, it is noted that the impact of FDI on CO_2 emissions is negative and statistically significant for Australia (-0.020), Canada (-0.013), Germany (-0.015), Italy (-0.013), New-Zealand (-0.043), Sweden (-0.020), and Switzerland (-0.048). It might be possible that in these countries, FDI helps in improving environmental quality by routing the investments in clean projects and deploying environment-friendly technologies. This segment of results complements the findings of Shahbaz et al. (2015) and Zhang and Zhou (2016). However, results also suggest the impact of FDI on CO_2 emissions to be positive and statistically significant for Austria (0.021), Chile (0.060), Denmark (0.053), Finland (0.034), France (0.083), and USA (0.049). It might be possible that for these countries, FDI inflow is towards the polluting industries along with more preference is provided towards economic growth rather than environmental protection, and owing to this, CO_2 emissions might increase. The findings complement the findings by Seker et al. (2015) for Turkey, Sapkota and Bastola (2017) for Latin America countries. Similarly, the long-run elasticity of natural resources abundance in regard to carbon emissions is negative and statistically significant in Canada (-0.062), Chile (-0.120), Denmark (-0.055), France (-1.717), Germany (-0.091), Italy (-0.200), Switzerland (-0.773), and the UK (-0.019). The negative relationship implies that high natural resources abundance helps controlling CO_2 emissions, as the need to import fossil energy sources is less (Shahabadi and Feyzi, 2016). This segment of outcome is complemented by the findings of Balsalobre-Lorente et al. (2018). In contrast, natural resources abundance has positive impact on carbon emissions in Finland (0.096), Mexico (0.039), and Portugal (0.369). This segment of outcome is complemented by the findings of Rafindadi et al. (2014) for selected Asia-Pacific countries. The one possible explanation of this positive relationship is that these countries use low quality natural resources (coal, oil, and natural gas) which may produce higher CO_2 emissions. The results specify that the renewable energy consumption diminish CO_2 emissions except in Netherlands, Norway, Switzerland, and Turkey. These results imply that green (renewable) energy consumption helps in reducing CO_2 emissions. However, energy consumption from renewable sources wields positive effect on carbon emissions in Canada (0.537) and Korea (0.143). One possible explanation of this segment of results is that renewable energy consumption in these countries might have not reached the threshold level, where energy consumption from renewable sources reduces carbon emissions. Forsberg (2009) explained that renewable energy might not help in lessening carbon emissions for poor scientific advancement used in renewable energy storage.

Lastly, the results of causality analysis are discussed. The main reason for conducting a causality analysis is that the policy directives are by and large bidirectional (Lu et al., 2014). Therefore, from the perspective of policymaking, it is very important to determine the associative directionality among model parameters. For this purpose, heterogeneous causality test by Dumitrescu and Hurlin (2012) is conducted, and test outcome are stated in Table-7. It can be noticed that feedback hypothesis is held between education and CO_2 emissions. Studies by Bano et al. (2018) also found evidence of feedback hypothesis for human capital-CO_2 emissions association. The empirical results indicate that CO_2 emissions also causally impact FDI. Seker et al. (2015) also reported unidirectional causal link was from CO_2 emission to FDI, whereas Al-mulali and Foon (2013) found no causal link between FDI and CO_2 emissions. The results also indicate that economic growth causes CO_2 emissions, whereas CO_2 emissions do not cause economic growth. The same results are reported Salahuddin et al. (2018) for Kuwait, and Koçak and Şarkgüneşi (2018) for Turkey. Moreover, we also found unidirectional causal relationship running from CO_2 emissions to natural resource abundance. This segment of our results contradicts the finding of Khan et al. (2016) in terms of neutrality hypothesis for natural resources rents-CO_2 emissions relationship in Pakistan.

However, the causal relationship between green energy and CO_2 emissions is bidirectional and similar results are reported by Hu et al. (2018). The test outcome also indicates consumption of renewable energy and education has a bidirectional causal association among each other. These results indicate that feedback hypothesis is held for education-renewable energy association. Economic growth and natural resources Granger cause FDI. However, the association between natural resources and economic growth is bidirectional for OECD countries. We also can notice that conservation hypothesis is held for economic growth-renewable energy association. These results are supported Furuoka (2017), who found unidirectional relationship is coming from economic growth to renewable energy.

6. Implications for sustainable development

Through the course of this study, the causal associations among the covariates and the long run elasticities have been explored, and it might help in formulating policies to ascertain sustainable development. The key finding is that education can reduce environmental degradation, and there exists a bidirectional causal association exists between education and environmental degradation. This provides with the first policy direction towards achieving the SDGs. Education endows a nation with the level of awareness, which a nation needs to retain environmental quality intact. The environmental awareness with proper education might bring forth several gross-root level innovations, which can shape the future of cleaner technologies. These innovations would not only open up several vocaional opportunities, but also will ensure social inclusion at different levels, which might be reflected in terms of emerging people-public-private partnerships (Sinha et al. 2017, 2018). In this regard, the objective of SDG 4, i.e. quality education, can be aligned with the objectives of (a) SDG 17, i.e. partnerships for the goals, (b) SDG 8, i.e. sustainable vocational prospects, (c) SDG 9, i.e. industry, innovations, and infrastructure, and (d) SDG 13, i.e. climate action.

While discussing about innovations and cleaner production technologies, associations between carbon emissions, green energy consumption and education give significant policy insights regarding the energy policy of these nations. It is noteworthy to observe that with rise in education, the consumption of renewable energy shows a rise, and it indicates the tendency of people to opt for green energy solutions. Moreover, economic growth pattern calls for consumption of green energy solutions, which is divulged by how economic growth causes renewable energy consumption. It also gives a direction towards the shifting from fossil fuel to renewable energy solutions in a phase-wise manner, as a unidirectional causal association also runs from economic growth to fossil fuel energy consumption (for similar results, see Zafar et al., 2019). Hence, with the intention of sustaining economic growth, the policymakers should consider a phase-wise transition of energy solutions. The established people-public-private partnerships might play an important role during this transition, by providing additional policy directives regarding the preservation of natural resource pool, so that the consumption of fossil fuel can be reduced through increase in environmental awareness. In this regard, the objective of SDG 7, i.e. cheap and green energy, can be traced back to the objectives of (a) SDG 4, i.e. quality education, and (b) SDG 13, i.e. climate action, and it can be aligned with the objective of SDG 12, i.e. responsible consumption and production.

In continuation with this discussion, it should also be noted that with the improvement of educational curriculum and technological progress in renewable energy solutions in OECD nations should be endogenous, and in this process, the dependence on technology import via FDI route should be reduced. In this way, the domestic industries will get a chance to revive, endogenous research and development will increase, vocational opportunities will rise, and CO_2 emissions will reduce. Lowering the dependence on FDI will allow these nations to have more control over the pool of natural resources, and thereby, the natural habitat of the flora and fauna can be sustained. This is substantiated by the positive impact of FDI on CO_2 emissions, which signifies the negative impact of FDI on environmental quality. Therefore, the policy design in these nations must look into the public property rights strictly, alongside implementation and incentivization of cleaner technologies in the existing and potential production processes (Roy et al., 2018; Sharif et al., 2020b). This can be possible only by means of rising level of environmental awareness through the revision of curriculum and improvement of education. In this regard, the objective of SDG 9, i.e. indusry, innovation and infrastructure, can be traced back to the objectives of (a) SDG 4, i.e. quality education, and (b) SDG 13, i.e. climate action, and it can be aligned with the objectives of (a) SDG 12, i.e. responsible consumption and production, (b) SDG 14, i.e. life below water, and (c) SDG 15, i.e. life on land.

7. Conclusions

The last few decades witnessed the world facing numerous challenges to regulate carbon emissions while keeping growth intact. Henceforth, various types of social and economic factors together can play crucial role in order to achieve sustainable environment. This empirical study is to investigate the possible impact of education, FDI, economic growth, abundance of natural resources, and consumption of renewable energy on carbon emissions in 27 OECD nations for 1990-2015. Using second generation methodological approach, this study has made an endeavor to design a policy framework for achieving the SDGs, while assessing the association between the mentioned model parameters. Based on the study outcomes, a policy framework has been suggested for the OECD countries in order to reduce carbon emissions by means of renewable energy consumption, and catalyzing this process through educational awareness. Through this framework, objectives of SDG 7 and SDG 13 will be achieved, while targeting the SDG 4. In this pursuit, objectives of allied SDGs, i.e. SDG 9, SDG 12, SDG 14, and SDG 15 might be achieved, which in turn will help in achieving the objective of SDG 8. This multipronged SDG policy framework is necessary for the OECD nations, given their position in achievement of the SDG objectives. The present study contributes to the literature of energy and environmental economics by bringing forth this aspect of multilevel policy designing before the economic researchers and policymakers. Now, the tentative implicational design of the policy framework will be discussed.

As education significantly reduces carbon emissions, it signifies that OECD countries can improve environmental quality by augmenting the environmental awareness via education system. Providing more stress on environmental benefits and energy efficiency at the curriculum will not only enhance environmental awareness among the citizens, but also will inculcate the culture of energy saving among the bourgeoning workforce. The improvement in curriculum should also be complemented by education by setting minimum educational qualification for potential vocational opportunities, so that the lessons of environmental awareness can be imbibed in prospective workforce at a deeper level. This will facilitate successful people-public-private partnership thereby decreasing the negative impact of FDI on environmental quality, by restricting import of polluting technologies and defining public property rights in a stricter manner. For policy formulation, OECD countries should formulate policies to attract FDI in energy efficient and clean technologies. They should also encourage organizations to adopt green technologies to produce lower carbon emissions by providing benefits, such as tax reliefs, and additional financial incentive. While these policies will come into practice, the governments of these nations should focus on retaining natural resource pool by defining the public property rights through people-public-private partnerships. This might in turn reduce the level of fossil fuel consumption and encourage the organizations to utilize the renewable energy solutions, and consequently, carbon emissions might come down. However, the policymakers should carry out this shift from fossil fuel to green energy solutions in a phase-wise manner; else economic growth pattern might be harmed during this transition. Now, this initiative will prove to be successful with the rise in environmental awareness among citizens, and in order to achieve it, it is necessary to update the curriculum at the school level, so that the students can know about the various ways to achieve energy efficiency and environmental sustainability. They should also look into increasing the budget in education, so that the students can get practical exposure on these aspects and can start innovating on these lines. In this way, education can lead to an endogenous sustainable green growth, which will be catalyzed by renewable energy solutions instead of fossil fuel use, development of the cleaner technologies by replacing the polluted technologies imported via FDI, and preservation of natural resources.

According to the analysis of individual countries, it becomes evident that education is an important factor to reduce carbon emissions in Finland, Sweden, Greece, Italy, Portugal, Luxembourg, Spain, Ireland, Switzerland, and UK. It would be rational policy for these countries to continuously increase the formal and informal educational attainment across the country. The results suggest that carbon emissions can be reduced due to improved environmental education in Belgium and Netherlands. These countries should increase their education budget and introduce environmental awareness in existing high school curriculum, as environmental sustainability can be achieved by spreading the informal education about environment. FDI improves the environmental quality in Ireland, Portugal, and Switzerland. These countries should continue to accept FDI and should focus on importing cleaner technological solutions by retaining the natural resources. Though, Chili government should need to implement policies to attract clean FDI from developed countries. The abundance of natural resource catalyzes carbon emissions, and it is visible in Australia, Finland, Mexico, Norway, Portugal, and Spain. These countries should develop policies to reduce the use of those natural resources, consumption of which causes the increase in carbon emissions. In contrast, the abundance of natural resource has negative impact on carbon emissions in Austria, Germany, Italy, Switzerland, and the UK. It would be a rational policy for these countries should be retaining natural resource pool. Overall, results suggest that renewable energy increases environment quality. These countries should continue investing in renewable energy domain to attain the goal of environmental sustainability. However, we also can notice that carbon emissions increase with renewable energy for Canada and South Korea. The focus of these countries should be on improving the attractiveness by offering different financial and tax relief incentives in renewable energy sector, as well as by increasing the research & development expenditures to minimize the cost of energy production from renewable sources.

There are few limitations of the study. Owing to the data availability, the analysis was restricted to only 27 OECD countries. Moreover, during the study period, there could be possible structural breaks appearing in the individual member countries, and this analysis didn't consider those structural breaks. As a future direction of the study, the individual member countries can be analyzed while considering the unknown structural breaks and segregating the data into quantiles, so that the policies for every member country can be analyzed at a much deeper level.

Reference

Akerlof, K., 2017. When Should Environmental Awareness Be a Policy Goal?. In Participatory Sensing, Opinions and Collective Awareness (pp. 305-336). Springer, Cham.

Almeida, P.S., Lopes, A.S., Oliveira, B.D., 2018. Sustainability in University Campuses and Environmental Education Policy: Complementary Governances Toward Consciousness Structure in Carbon Emissions Reductions. In Towards Green Campus Operations (pp. 197-204). Springer, Cham.

Al-mulali, U., Foon, C., 2013. Investigating the validity of pollution haven hypothesis in the gulf cooperation council (GCC) countries. Energy Policy, 60, 813–819.

Apergis, N., Payne, J.E., Menyah, K., Wolde-Rufael, Y., 2010. On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. Ecological Economics, 69(11), 2255–2260.

Auteri, M., Constantini, M., 2005. Intratemporal Substitution and Government Spending: Unit Root and Cointegration Tests in a Cross Section Correlated Panel. 17th conference Paper, Societa Italiana Di Economia Pubblica, Pavia, Universita.

Bai, J., Kao, C., Ng, S., 2009. Panel cointegration with global stochastic trends. Journal of Econometrics, 149(1), 82–99.

Balaguer, J., Cantavella, M., 2018. The role of education in the Environmental Kuznets Curve. Evidence from Australian data. Energy Economics, 70, 289–296.

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., Farhani, S., 2018. How economic growth, renewable electricity and natural resources contribute to CO_2 emissions? Energy Policy, 113, 356–367.

Bano, S., Zhao, Y., Ahmad, A., Wang, S., Liu, Y., 2018. Identifying the impacts of human capital on carbon emissions in Pakistan. Journal of Cleaner Production, 183, 1082-1092.

Bao, Q., Chen, Y., Song, L., 2008. The environmental consequences of foreign direct investment in China. Environment and Development Economics, 16, 71–92.

Barber, J., 2007. Mapping the movement to achieve sustainable production and consumption in North America. Journal of Cleaner Production, 15(6), 499-512.

Baumeister, S., 2018. We Are Still In! Conference report from the 2018 Ceres Conference. Journal of Cleaner Production, 196, 183-184.

Behera, S.R., Dash, D.P., 2017. The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. Renewable and Sustainable Energy Reviews, 70, 96-106.

Bisbis, M.B., Gruda, N., Blanke, M., 2018. Potential impacts of climate change on vegetable production and product quality–A review. Journal of Cleaner Production, 170, 1602-1620.

Breusch, T.S., Pagan, A.R., 1980. The Lagrange multiplier test and its applications to model specification in econometrics. The Review of Economic Studies, 47(1), 239–253.

Constant, K., Davin, M., 2018. Environmental Policy and Growth when Environmental Awareness is Endogenous. Macroeconomic Dynamics, 23(3), 1102-1136.

Chirisa, I., Matamanda, A.R., 2019. Science Communication for Climate Change Disaster Risk Management and Environmental Education in Africa. In Building Sustainability Through Environmental Education (pp. 190-212). IGI Global.

Danish, Zhang, B., Wang, B., Wang, Z., 2017. Role of renewable energy and non-renewable energy consumption on EKC: Evidence from Pakistan. Journal of Cleaner Production, 156, 855–864.

Dumitrescu, E.I., Hurlin, C., 2012. Testing for Granger non-causality in heterogeneous panels.

Economic Modelling, 29(4), 1450-1460.

Eastin, J., 2018. Climate change and gender equality in developing states. World Development, 107, 289-305.

Emiru, T.S., Waktola, D.K., 2018. The environmental awareness of higher education students and the implications for the Paris Climate Agreement: empirical evidences from Ethiopia and USA. International Research in Geographical and Environmental Education, 27(3), 216-233.

Faize, F.A., Akhtar, M., 2020. Addressing environmental knowledge and environmental attitude in undergraduate students through scientific argumentation. Journal of Cleaner Production, 252, 119928.

Farhani, S., Shahbaz, M., 2014. What role of renewable and non-renewable electricity consumption and output is needed to initially mitigate CO_2 emissions in MENA region? Renewable and Sustainable Energy Reviews, 40, 80–90.

Figueres, C., Le Quéré, C., Mahindra, A., Bäte, O., Whiteman, G., Peters, G., Guan, D., 2018. Emissions are still rising: ramp up the cuts. Nature, 570, 27-30.

Forsberg, C.W., 2009. Sustainability by combining nuclear, fossil, and renewable energy sources. Progress in Nuclear Energy, 51(1), 192–200.

Frank, D.J., Hironaka, A., Schofer, E., 2000. The nation-state and the natural environment over the twentieth century. American Sociological Review, 65(1), 96-116.

Furuoka, F., 2017. Renewable electricity consumption and economic development: New findings from the Baltic countries. Renewable and Sustainable Energy Reviews, 71, 450–463.

Gangadharan, L., Valenzuela, M.R., 2001. Interrelationships between income, health and the environment: Extending the environmental kuznets curve hypothesis. Ecological

Economics, 36(3), 513–531.

Grossman, G.M., Krueger, A.B., 1991. Environmental impacts of a North American free trade agreement (No. w3914). National Bureau of Economic Research.

Hakimi, A., Hamdi, H., 2016. Trade liberalization, FDI inflows, environmental quality and economic growth : A comparative analysis between Tunisia and Morocco. Renewable and Sustainable Energy Reviews, 58, 1445–1456.

He, J., 2006. Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO_2) in Chinese provinces. Ecological Economics, 60(1), 228–245.

Hess, D.J., Collins, B.M., 2018. Climate change and higher education: Assessing factors that affect curriculum requirements. Journal of Cleaner Production, 170, 1451-1458.

Hill, R.J., Magnani, E., 2002. An exploration of the conceptual and empirical basis of the environmental kuznets curve. Australian Economic Papers, 41(2), 239-254.

Hu, H., Xie, N., Fang, D., Zhang, X., 2018. The role of renewable energy consumption and commercial services trade in carbon dioxide reduction: Evidence from 25 developing countries. Applied Energy, 211, 1229–1244.

International Energy Agency (IEA), 2017. Renewables information: overview (2017 edition).

Jebli, M.B., Youssef, S.B., Ozturk, I., 2016. Testing environmental Kuznets curve hypothesis: The role of renewable and non-renewable energy consumption and trade in OECD countries. Ecological Indicators, 60, 824-831.

Jiang, Y., 2015. Foreign Direct Investment, Pollution, and the Environmental Quality: A Model with Empirical Evidence From the Chinese Regions. The International Trade Journal, 29(3), 212–227.

Khan, M.M., Zaman, K., Irfan, D., Awan, U., Ali, G., Kyophilavong, P., … Naseem, I., 2016. Triangular relationship among energy consumption, air pollution and water resources in Pakistan. Journal of Cleaner Production, 112, 1375–1385.

Koçak, E., Şarkgüneşi, A., 2018. The impact of foreign direct investment on CO_2 emissions in Turkey: new evidence from cointegration and bootstrap causality analysis. Environmental Science and Pollution Research, 25(1), 790–804.

Ketlhoilwe, M.J., 2019. Building Community Resilience Through Environmental Education: A Local Response to Climate Change. In Building Sustainability Through Environmental Education (pp. 1-21). IGI Global.

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

Lozano, F.J., Lozano, R., Freire, P., Jiménez-Gonzalez, C., Sakao, T., Ortiz, M. G., ... &Viveros, T., 2018. New perspectives for green and sustainable chemistry and engineering: Approaches from sustainable resource and energy use, management, and transformation. Journal of Cleaner Production, 172, 227-232.

Lu, W., Chau, K.W., Wang, H., Pan, W., 2014. A decade's debate on the nexus between corporate social and corporate financial performance: a critical review of empirical studies 2002–2011. Journal of Cleaner Production, 79, 195-206.

Managi, S., Jena, P.R., 2008. Environmental productivity and Kuznets curve in India. Ecological Economics, 65(2), 432–440.

Mantovani, A., Tarola, O., Vergari, C., 2017. End-of-pipe or cleaner production? How to go green in presence of income inequality and pro-environmental behavior. Journal of Cleaner Production, 160, 71-82.

Meadows, D.L., 1974. Limits to Growth a Finite World. Cambridge University Press.

Morin, J.F., Dür, A., Lechner, L., 2018. Mapping the Trade and Environment Nexus: Insights from a New Data Set. Global Environmental Politics, 18(1), 122-139.

OECD, 2017. OECD and the Sustainable Development Goals: Delivering on universal goals and targets. Available at: http://www.oecd.org/development/sustainable-development-goals.htm

OECD, 2019. Measuring Distance to the SDG Targets 2019: An Assessment of Where OECD Countries Stand. Organisation for Economic Co-operation and Development.

Pan, X., Uddin, M.K., Ai, B., Pan, X., Saima, U., 2019. Influential factors of carbon emissions intensity in OECD countries: Evidence from symbolic regression. Journal of Cleaner Production, 220, 1194-1201.

Panayotou, T., 1993. Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working Paper No. 292778, International Labour Organization, Geneva.

Pao, H. T., Tsai, C.M., 2011. Multivariate Granger causality between CO_2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. Energy, 36(1), 685-693.

Pashollari, E., 2019. Building Sustainability Through Environmental Education: Education for Sustainable Development. In Building Sustainability Through Environmental Education (pp. 72-88). IGI Global.

Pauli, G., 1997. Zero emissions: the ultimate goal of cleaner production. Journal of Cleaner Production, 5(1-2), 109-113.

Pazienza, P., 2015. The environmental impact of the FDI inflow in the transport sector of OECD countries and policy implications. International Advances in Economic Research, 21(1), 105-116.

Pesaran, M.H., 2004. General Diagnostic Tests for Cross Section Dependence in Panels. Discussion Paper No. 1240, IZA, Bonn, Germany.

Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. Journal of Applied Econometrics, 22(2), 265–312.

Pesaran, M.H., Shin, Y., Smith, R.P., 1999. Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. Journal of the American Statistical Association, 94(446), 621–634.

Phillips, P.C.B., Sul, D., 2003. Dynamic panel estimation and homogeneity testing under cross section dependence. The Econometrics Journal, 6(1), 217–259.

Polzin, F., Migendt, M., Täube, F.A., von Flotow, P., 2015. Public policy influence on renewable energy investments—A panel data study across OECD countries. Energy Policy, 80, 98-111.

Puukka, J., 2008. Mobilising higher education for sustainable development–lessons learnt from the OECD study. Global University Network for Innovation, Barcelona.

Quéré, C.L., Andrew, R.M., Friedlingstein, P., Sitch, S., Pongratz, J., Manning, A.C., ... & Boden, T.A., 2018. Global Carbon Budget 2017. Earth System Science Data, 10(1), 405-448.

Rafindadi, A.A., Yusof, Z., Zaman, K., Kyophilavong, P., Akhmat, G., 2014. The relationship between air pollution, fossil fuel energy consumption, and water resources in the panel of selected Asia-Pacific countries. Environmental Science and Pollution Research, 21(19), 11395–11400.

Ramírez, F., Santana, J., 2019. Environmental Education and Biodiversity Conservation. In

Environmental Education and Ecotourism (pp. 7-11). Springer, Cham.

Roy, V., Schoenherr, T., Charan, P., 2018. The thematic landscape of literature in sustainable supply chain management (SSCM). International Journal of Operations & Production Management, 38(4), 1091-1124.

Roy, V., Singh, S., 2017. Mapping the business focus in sustainable production and consumption literature: Review and research framework. Journal of Cleaner Production, 150, 224-236.

Saifullah, M.K., Kari, F.B., Ali, M.A., 2017. Linkage between Public Policy, Green Technology and Green Products on Environmental Awareness in the Urban Kuala Lumpur, Malaysia. Journal of Asian Finance, Economics and Business, 4(2), 45-53.

Sánchez-Llorens, S., Agulló-Torres, A., Del Campo-Gomis, F.J., Martinez-Poveda, A., 2019. Environmental consciousness differences between primary and secondary school students. Journal of Cleaner Production, 227, 712-723.

Sarti, M., John, S.K.S., 2019. Raising Long-Term Awareness: EU Environmental Policy and Education. In Education and Public Policy in the European Union (pp. 165-181). Palgrave Macmillan, Cham.

Salahuddin, M., Alam, K., Ozturk, I., Sohag, K., 2018. The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait. Renewable and Sustainable Energy Reviews, 81, 2002–2010.

Sapkota, P., Bastola, U., 2017. Foreign direct investment, income, and environmental pollution in developing countries: Panel data analysis of Latin America. Energy Economics, 64, 206–212.

Sbia, R., Shahbaz, M., Hamdi, H., 2014. A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE.

Economic Modelling, 36, 191–197.

Seker, F., Murat, H., Cetin, M., 2015. The impact of foreign direct investment on environmental quality : A bounds testing and causality analysis for Turkey. Renewable and Sustainable Energy Reviews, 52, 347–356.

Shafiei, S., Salim, R.A., 2014. Non-renewable and renewable energy consumption and CO_2 emissions in OECD countries: A comparative analysis. Energy Policy, 66, 547-556.

Shahabadi, A., Feyzi, S., 2016. The Relationship between Natural Resources Abundance, Foreign Direct Investment and Environmental Performance in Selected Oil and Developed Countries during 1996-2013. International Journal Resistive Economics, 4, 101–116.

Shahbaz, M., Nasir, M.A., Roubaud, D., 2018. Environmental degradation in France: The effects of FDI, financial development, and energy innovations. Energy Economics, 74, 843–857.

Shahbaz, M., Nasreen, S., Abbas, F., Anis, O., 2015. Does foreign direct investment impede environmental quality in high-, middle-, and low-income countries? Energy Economics, 51, 275–287.

Shahbaz, M., Sinha, A., 2019. Environmental Kuznets Curve for CO_2 Emissions: A Literature Survey. Journal of Economics Studies, 46(1), 106-168.

Shahbaz, M., Balsalobre-Lorente, D., Sinha, A., 2019. Foreign direct Investment–CO_2 emissions nexus in Middle East and North African countries: Importance of biomass energy consumption. Journal of Cleaner Production, 217, 603-614.

Sharif, A., Baris-Tuzemen, O., Uzuner, G., Ozturk, I., Sinha, A., 2020a. Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. Sustainable Cities and Society, 57, 102138.

Sharif, A., Mishra, S., Sinha, A., Jiao, Z., Shahbaz, M., Afshan, S., 2020b. The renewable energy consumption-environmental degradation nexus in Top-10 polluted countries: Fresh insights from quantile-on-quantile regression approach. Renewable Energy, 150, 670-690.

Sinha, A., Shahbaz, M., 2018. Estimation of Environmental Kuznets Curve for CO_2 emission : Role of renewable energy generation in India. Renewable Energy, 119, 703–711.

Sinha, A., Shahbaz, M., Balsalobre, D., 2017. Exploring the relationship between energy usage segregation and environmental degradation in N-11 countries. Journal of Cleaner Production, 168, 1217-1229.

Sinha, A., Shahbaz, M., Sengupta, T., 2018. Renewable Energy Policies and Contradictions in Causality: A case of Next 11 Countries. Journal of Cleaner Production, 197, 73-84.

Sinha, A., Gupta, M., Shahbaz, M., Sengupta, T. 2019. Impact of corruption in public sector on environmental quality: Implications for sustainability in BRICS and next 11 countries. Journal of Cleaner Production, 232, 1379-1393.

Sinha, A., Sengupta, T., Alvarado, R., 2020. Interplay between technological innovation and environmental quality: formulating the SDG policies for next 11 economies. Journal of Cleaner Production, 242, 118549.

Solarin, S.A., Al-Mulali, U., Musah, I., Ozturk, I., 2017. Investigating the pollution haven hypothesis in Ghana: An empirical investigation. Energy, 124, 706–719.

Stevenson, C.N., 2019. Addressing the Sustainable Development Goals Through Environmental Education. In Building Sustainability Through Environmental Education (pp. 121-148). IGI Global.

Westerlund, J., 2008. Panel Cointegration Tests of the Fisher Effect. Journal of Applied

Econometrics, 23, 193–233.

World Bank, 2018. World Development Indicators. Available at: https://data.worldbank.org/indicator

Zafar, M.W., Shahbaz, M., Hou, F., Sinha, A., 2019. From Nonrenewable to Renewable Energy and Its Impact on Economic Growth: The role of Research & Development Expenditures in Asia-Pacific Economic Cooperation Countries. Journal of Cleaner Production, 212, 1166-1178.

Zhang, C., Zhou, X., 2016. Does foreign direct investment lead to lower CO_2 emissions? Evidence from a regional analysis in China. Renewable and Sustainable Energy Reviews, 58, 943–951.

Zhu, H., Duan, L., Guo, Y., Yu, K., 2016. The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression. Economic Modelling, 58, 237-248.

Zhu, Q., Sarkis, J., Lai, K.H., 2018. Regulatory policy awareness and environmental supply chain cooperation in China: A regulatory-exchange-theoretic perspective. IEEE Transactions on Engineering Management, 65(1), 46-58.

Table 1: Cross-sectional dependence test results

	Breusch-Pagan LM	Pesaran scaled LM	Pesaran CD
CO_2	4515.142***	117.0322***	30.231***
EDU	1515.667***	42.938***	8.088***
EDU^2	1464.869***	41.021***	7.947***
FDI	769.285***	14.768***	3.136***
FDI^2	937.079***	21.101***	6.509***
GDP	1454.716***	40.638***	7.909***
GDP^2	1476.318***	41.453***	9.145***
NR	990.089***	23.101***	4.953***
NR^2	1067.360***	26.018***	5.580***
RNE	2423.745***	77.211***	51.40***
Note: *** shows significant at 1% level.			

Table 2: Unit root test results

	CIPS		CADF	
variables	Level	First difference	Level	First difference
CO_2	-2.067	-4.651***	-2.117	-3.400***
EDU	-1.960	-3.807***	-2.395	-3.052***
EDU^2	-1.913	-3.812***	-2.364	-3.035***
FDI	-3.933***	-5.835***	-2.454	-3.402***
FDI^2	-3.924***	-5.931***	-2.160	-3.148***
GDP	-2.047	-3.530***	-1.803	-2.834***
GDP^2	-2.082	-3.548***	-2.141	-2.853***
NR	-2.267	-4.262***	-2.026	-3.533***
NR^2	-2.605	-4.845***	-2.280	-3.922***
RNE	-2.471	-3.389***	-2.133	-3.451***
Note: *** shows significant at 1% level.				

Table 3: Westerlund cointegration test results

	T-statistics
DH-panel	-4.112***
DH-group	-3.010***
Note: *** shows significant at 1% level.	

Table 4. Linear Long-run elasticities

	CUP-FM		CUP-BC		Pool Mean Group (PMG)	
	Coefficient	T-statistics	Coefficient	T-statistics	Coefficient	T-statistics
EDU	-0.0278***	3.337	-0.0188**	2.775	-0.2316***	3.014
FDI	0.0004***	28.578	0.0011***	27.820	0.0044*	1.812
GDP	0.6025***	25.921	0.6550***	28.038	0.5073***	5.895
NR	0.0014***	15.973	0.0014***	13.137	0.04295**	2.145
RNE	-0.0788***	21.180	-0.0760***	20.612	-0.1822***	13.058
Note: ***, ** and * show significant at 1%, 5% and 10% levels respectively.						

Table 5. Nonlinear Long-run elasticities

	CUP-FM		CUP-BC		Pool Mean Group (PMG)	
Independent	Coefficient	T-statistics	Coefficient	T-statistics	Coefficient	T-statistics
EDU	1.6798***	5.196	1.5204***	4.740	23.658***	6.243
EDU^2	-0.1888**	6.483	-0.1711*	6.012	-2.450***	-6.285
FDI	-0.0014*	-17.929	-0.0005**	-17.002	-0.059*	-1.871
FDI^2	0.0004*	203.849	0.0003**	206.014	0.003*	1.812
GDP	4.3213***	22.461	4.0012***	21.348	17.147***	6.469
GDP^2	-0.2006***	24.756	-0.1843***	23.612	-0.818***	-6.468
NR	0.0003**	7.512	0.0020*	6.891	0.655***	3.990
NR^2	-0.0001*	67.886	-0.0003**	67.824	-0.052***	-3.906
RNE	-0.0490***	22.964	-0.0512***	23.638	-0.080***	-7.342
Note: ***, ** and * show significant at 1%, 5% and 10% levels respectively.						

Table-6 Time series analysis by using FMOLS

Country	EDU	FDI	GDP	NR	RNE	C	R-square	Adj-R-square
Australia	-0.059 (0.928)	-0.025** (-2.408)	0.502*** (7.297)	0.003 (0.220)	-0.394*** (16.264)	-7.559*** (9.346)	0.905	0.881
Austria	-1.394* (-1.843)	0.021* (1.752)	0.149 (0.565)	-0.129 (-1.478)	-0.799*** (-3.544)	2.139 (0.289)	0.562	0.452
Belgium	-0.069* (1.767)	0.006 (0.681)	0.392 (0.919)	-0.099 (0.343)	-0.156*** (-8.401)	6.916* (2.033)	0.919	0.899
Canada	-0.770** (-2.221)	-0.013* (-1.760)	1.348*** (4.960)	-0.062** (2.372)	0.537* (1.920)	14.877*** (3.650)	0.751	0.673
Chile	-0.034 (0.221)	0.060* (1.742)	1.810*** (5.378)	-0.120* (1.947)	-0.268*** (3.408)	-18.210*** (-5.171)	0.974`	0.967
Denmark	-0.593 (0.750)	0.053* (1.969)	3.749*** (3293)	-0.055* (-1.922)	-0.634*** (-4.660)	44.590*** (3.015)	0.823	0.779
Finland	-0.481*** (-5.394)	0.034** (2.509)	0.060 (0.611)	0.096*** (4.410)	-0.461*** (5.218)	2.467 (1.264)	0.595	0.493
France	0.278 (0.407)	0.083* (2.007)	1.564** (2.724)	-1.717*** (5.039)	-0.704*** (4.753)	-14.210** (2.540)	0.659	0.574
Germany	-0.451 (-1.543)	-0.015*** (-2.855)	0.617* (1.738)	-0.091*** (3.452)	-0.184*** (3.518)	3.881 (0.665)	0.910	0.888
Greece	-0.801** (-2.114)	-0.004 (-0.616)	0.754*** (11.246)	0.026 (0.801)	-0.111*** (3.284)	-3.634 (1.475)	0.914	0.892

Ireland	-2.598 (0.889)	0.008 (0.283)	0.484*** (4.418)	-0.012 (0.302`)	-0.271*** (-5.853)	-5.637** (2.630)	0.886	0.857
Israel	-0.548 (0.975)	-0.032 (0.774)	0.816* (1.820)	0.044 (0.997)	-0.079*** (3.309)	-5.212 (0.8375)	0.310	0.419
Italy	-1.347** (-2.815)	-0.013* (-1.834)	2.155*** (5.137)	-0.200*** (-3.856)	-0.281*** (-3.322)	-16.323*** (8.216)	0.930	0.913
Japan	0.247 (0.417)	-0.004 (-1.318)	0.255* (1.919)	0.117 (1.493)	-0.093** (2.661)	-3.788* (1.771)	0.450	0.313
South-Korea	0.574* (1.988)	-0.029 (-1.642)	1.811*** (4.125)	0.046 (0.396)	0.143* (1.776)	-15.062*** (-4.683)	0.960	0.948
Luxembourg	-1.912*** (-7.472)	0.018 (0.753)	2.186*** (7.077)	0.044 (0.702)	-0.575*** (-5.795)	-22.259*** (5.264)	0.751	0.688
Mexico	0.489*** (2.926)	-0.020 (0.990)	0.846*** (3.947)	0.039*** (3.210)	-0.139*** (2.933)	-10.284 (5.2888)	0.823	0.765
Netherlands	0.082 (0.400)	0.008 (.621)	0.568** (2.217)	-0.005 (0.660)	0.161 (0.987)	-1.988 (0.524)	0.666	0.561
N-Zealand	0.310 (0.977)	-0.043* (-1.980)	1.480** (2.550)	-0.016 (1.269)	-0.297** (2.763)	-18.373** (2.515)	0.418	0.270
Norway	-0.068 (0.061)	0.044 (1.042)	-0.008 (0.021)	0.259* (2.494)	0.475 (0.934)	-4.631 (0.603)	0.255	0.069
Portugal	-0.262 (-1.338)	-0.005 (-0.315)	0.571*** (3.682)	0.369*** (6.793)	-0.145*** (-3.237)	-7.307*** (-4.411)	0.766	0.708
Spain	-1.262** (2.211)	-0.010 (0.230)	1.330** (2.414)	0.091 (0.304)	-0.238** (2.479)	-9.569* (1.921)	0.791	0.739
Sweden	-0.075 (-1.115)	-0.020** (2.200)	-0.423*** (4.842)	0.010 (0.682)	-0.393*** (4.490)	1.817 (1.101)	0.728	0.660
Switzerland	-2.190*** (-4.291)	-0.048*** (-3.706)	0.126 (0.306)	-0.773*** (-3.418)	-0.127 (0.811)	15.233*** (2.956)	0.872	0.842
Turkey	-0.203* (1.825)	-0.007 (-0.511)	0.524*** (3.261)	0.016 (0.812)	-0.020 (0.484)	-3.165 (1.645)	0.973	0.965
UK	-0.070 (0.667)	-0.000 (0.041)	0.600*** (3.540)	-0.019** (-2.141)	-0.255*** (10.226)	-7.620 (3.423)	0.953	0.941
USA	-0.331 (0.585)	0.049** (2.493)	-0.579*** (4.643)	0.011 (0.977)	-0.397*** (-6.206)	4.010 (1.646)	0.786	0.732

Table 7. Pairwise Dumitrescu Hurlin Panel Causality Tests

Dependent	Independent variable					
	CO_2	EDU	FDI	GDP	NR	RNE
CO_2	-	2.0176**	-0.0435	6.6781***	1.5834	5.5574***
EDU	6.4533***	-	0.0957	1.1303	0.3747	2.6814***
FDI	2.5485**	1.1654	-	4.8755***	1.7419*	0.5040
GDP	1.4423	1.0567	1.1556	-	4.1960***	0.6340
NR	3.5529***	1.5510	0.9391	2.6691***	-	1.3735
RNE	2.0273**	3.0217***	0.8289	2.7090***	1.3574	-

Note: ***, ** and * show significant at 1%, 5% and 10% levels respectively.

Appendix 1: Correlation matrix

	CO_2	FDI	GDP	EDU	NR	RNE
CO_2	1.0000	-	-	-	-	-
FDI	0.3639	1.0000	-	-	-	-
GDP	0.6406	0.5433	1.0000	-	-	-
EDU	0.3496	0.3386	0.5233	1.0000	-	-
NR	0.2246	0.2147	0.4778	0.1770	1.0000	-
RNE	-0.0244	0.1715	0.3966	0.2446	0.0127	1.0000

Appendix 2: Multicolinearity analysis

	Before transformation		After transformation	
	VIF	Tolerance	VIF	Tolerance
CO_2	1.46	0.4706	1.00	1.0000
FDI	1.20	0.6947	1.00	1.0000
GDP	2.03	0.2419	1.00	1.0000
EDU	1.18	0.7144	1.00	1.0000
NR	1.21	0.6873	1.00	1.0000
RNE	1.24	0.6460	1.00	1.0000

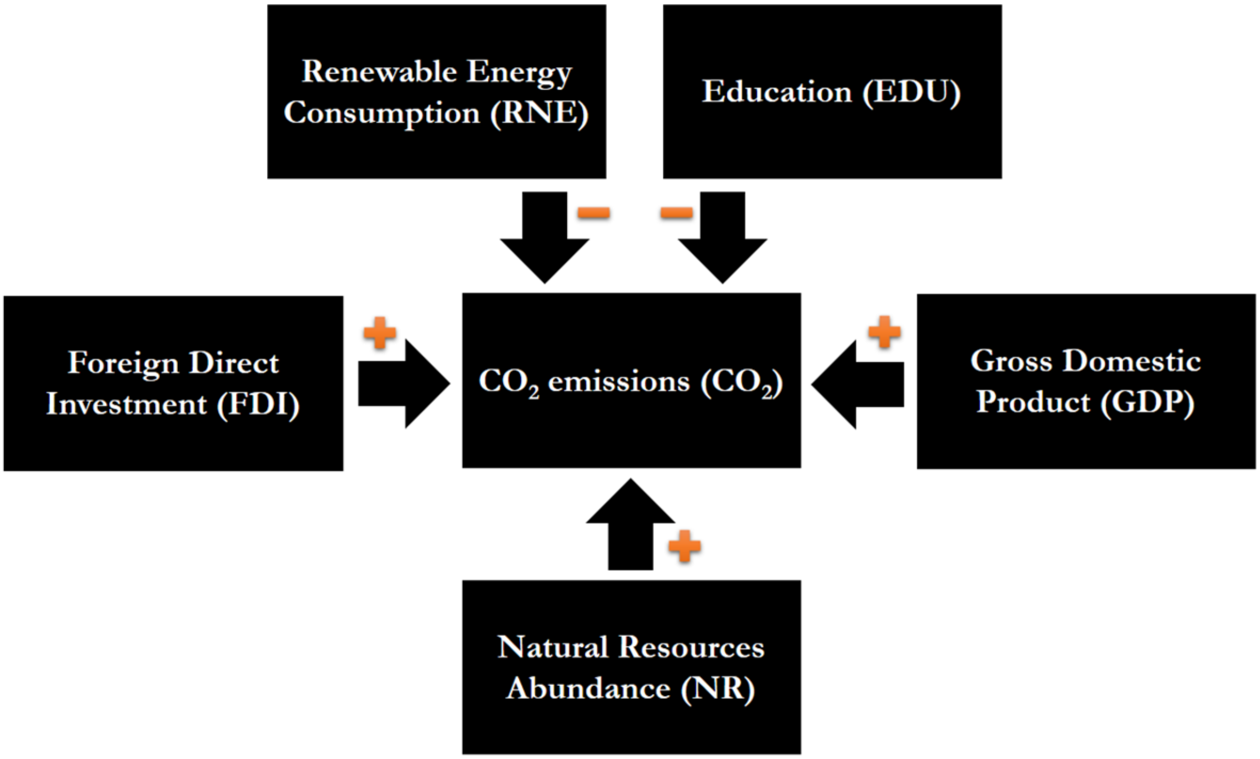

Figure-1: Theoretical Model