Is Achieved Economic Development Environment Friendly? A New Insight From Central and Eastern Europe

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Research Article

Keywords: OFDI, Renewable Energy, Natural Resource, EFP, GDPC

Posted Date: August 4th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-673353/v1

Is Achieved Economic Development Environment Friendly? A New Insight from Central and Eastern Europe

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Abstract

Over the last few years, the linkage between economic development and environmental degradation has become a provocative question. Although this nexus has been studied vastly, some of the critical variables of economic development and their impacts on the environment need more focus. The present study explores the association between economic development, outward foreign direct investment, financial development, renewable energy consumption, natural resource rents, trade openness, and ecological footprint in Central and Eastern European economies. The panel data estimators such as augmented mean group and common correlated effect mean group are employed from 1990 to 2017. Empirical findings document that outward foreign direct investment, financial development, trade openness, natural resource rents, and renewable energy consumption increase economic development, implying that they positively affect economic development. Findings validate the inverted U-shaped EKC for concerned economies in case of the ecological footprint. The results show that the interaction term of GDPC with NR, outward foreign direct investment, and RE are eco-friendly indicators. The study results develop imperative policy implications for the selected region to attain sustainable development goals.

Keywords: OFDI; Renewable Energy; Natural Resource, EFP; GDPC

1. Introduction

Considering global and regional economic assimilation, multinational enterprises as participants of international direct investment have gradually become organizers and watchdogs of universal resource provision. Foreign direct investment has quickly developed since the 1980s. Outward foreign direct investment (OFDI) raised from 243.8 billion USD in 1990 to 1014 billion in 2018,

above international trade growth during the same period (Chen et al. 2020). Quick science and progressive technology have fetched both adjustment and disintegration of universal production. Nations worldwide are aggressively contributing to international economic and trade collaboration both in depth and extent. Abridged trade obstacles deliver multinational corporations with optimum resource apportionment on a worldwide scale.

The outcome of the universal macro tendency is catalyzing the microeconomic internationalization process has witnessed an extraordinary scale within the composite scheme of Central and Eastern Europe (CEE) nations (Radlo and Sass 2012). For these economies, the indicated process instigated the transition of their post centrally planned nations into the free-market economic system. These procedures result in the gradual growth of OFDI stocks, which show the robust hysteresis that could be elucidated by Dunning and Narula's macroeconomic investment development path theory (Dunning 1982; Dunning 2002) that is consistent with the dynamical adaptive complex system (Kwapień and Drożdż 2012). The theory associates with movements of per capita FDI and the level of economic development, which further deviate the arrangement of market in terms of international trade patterns and regional supply chains. According to Kolstad and Wiig (2012), investors of developed economies prefer to invest in the countries with abundant natural resources (NR) and poor environmental laws.

Little literature prevails the influence of NR abundance on economic growth. The negative sway of NR on the GDP was firstly introduced by the NR curse hypothesis (Sachs and Warner 1995). Later on, Atkinson and Hamilton (2003) and Gylfason and Zoega (2006) suggested the role of investment, and they estimated the impact of NRs on physical capital and GDP. Further, Smith (2015) quantified the effect of NR reservoirs and mines since 1950 on GDPC. Likewise, trade openness (TO) also plays a vital role in the progress of an economy, and there are different ways by which TO increases real GDPC in resource-rich countries. It may be possible that an increase in the level of trade helps to lessen the negative impact of NR rents on per capita income by efficient resource management. Trade offers access to the international market and elevated prices for their goods. Though, it helps to introduce modern technologies for more effective abstraction of NR. With the use of innovative technologies, NR rich economies can manufacture intermediate and final products from primary good and earn more profit. TO assists to update the whole economy by upgrading of local infrastructure (Pedersen 2000), the financial sector (Braun

and Raddatz 2008), and the bureaucratic system (Dutt 2009). Generally, TO plays a vital role in altering NR into a blessing rather than a curse.

Domestic finance creation can be seen as one innovation category that is capable to accelerate GDP. Financial development (FD) has received a considerable attention in the empirical literature. Cross-sectional studies found the positive effect of FD on growth [refers: Durusu-Ciftci et al. (2017); Yang (2019); Erdoğan et al. (2020)], while, a case study found the negative influence of FD on growth (Cheng et al. 2020). Consequently, development is strongly linked with energy as it is considered diriver of economy. Primary energy consumption has increased approximately 2.2 percent (Dudley 2018). While the share of RE energy consumption is significantly lower than NRE usage in the global energy portfolio. RE is a possible way for the diversification of resources and less reliance on fossil fuels means greater tolerance to energy shocks. However, it can be challenging to move from non-RE to RE production. The high initial expense is one of the most significant issues for RE. In contrast with non-RE-based energy expenditure, many financial barriers need to be met, including higher start-up infrastructure and operating costs. Therefore, economies want to attain economic development across the world while ignoring its harmful impact on environment.

To estimate the impact of achieved GDPC on the environment, we have used ecological footprint (EFP) as a proxy of environment quality. The abundance of researches takes CO_2 as a proxy of environmental degradation while studying the nexus of GDP and the environment (Wu et al. 2019; Awodumi and Adewuyi 2020). However, CO_2 is a proportion of all pollution, but it is alone insufficient to count complete environmental degradation. Recently, the EFP of Wackernagel and Rees (1998) is assumed as the new inclusive variable to measure the extent of environmental degradation as it reflects cropland, grazing land, fishing grounds, forestland, carbon footprint, and built-up land. The key objective is to examine the effect of economic development and other variables of interest on the EFP for 1990-2017 in the selected 16 CEE economies.

Several studies have focused the economic growth and environmental quality, but there is no state of the art analysis which tries to estimate the impact of achieved economic development and its determinants on EFP. Henceforth, this paper highlights the recent theoretical and empirical developments in the sustainable environment domain and answers the question, which

is not yet addressed by literature, but researchers and practitioners are eager to know more about it. Countries worry about per capita income to contend with other countries but ignore the adverse environmental effects. This paper addresses the per capita income in the CEE economies with environmental aspects and suggests how harmful consequences of economic development can be reduced. In addition, this work is prevailing literature in three ways; firstly, this is the first study to quantify the impact of different economic indicators on economic development to solve whether selected indicators are enhancing economic development in the CEE economies? Secondly, the main problem, of the world is environment pollution and this study answered the critical question, is achieved economic development, with its determinants eco-friendly or not? Thirdly, we have used the different advanced econometric techniques, i.e., Cross-sectional dependency (CD) tests and Westerlund cointegration those permit for CD. After inspection of the robustness of Westerlund, the Augmented mean group (AMG) and Common correlated effect mean group (CCE-MG) are used to examine the long-run association in both models. While addressing these goals, the results found in this study give the policy level information to device the development, economic, and environmental policies to attain sustainable development.

Further, this paper contains four parts i.e. literature review, data and methods, results and discussion, and in the last conclusion and policy recommendatios.

2. Literature review

Since the last decade, much work has been done to quantify the linkage between economic growth, NR income, and the environment by ensuring the Environment Kuznets curve (EKC) hypothesis. There is still a deficiency in the literature regarding the selection of environmental indicators. Thus, current study emphasizes on nexus of OFDI, FD, NR rents, RE, GDPC and the environment for selected CEE economies. Here, we will debate the studies, which are carried out to assess selected macro-economic variables on economic development. Simultaneously, in the second face, we have focused on economic development with its selected environmental degradation determinants.

2.1. Impact of OFDI, NR, TO, FD, and RE on Economic Development

Scientists have directed widespread research to discover the link between the OFDI, NR, TO, FD, and RE consumption with economic growth or development for time series and panel

studies. Different studies have different findings regarding growth or development indicators. Even though preceding work has delivered some understanding of the belongings of concerning indicators on growth. The studies yet have some shortcomings connecting to exclusions of specific factors that are assumed to contribute to GDP.

Shakouri and Khoshnevis Yazdi (2017) studied the linkage between GDP and RE in South Africa and supported the evidence of the positive association between the growth and RE. A study by Li et al. (2017) for emerging economies and found OFDI as the main driver of growth. Ohlan (2018) explored the positive association of energy use and grwoth. Dwumfour and Ntow-Gyamfi (2018) exposed the positive relationship between economic development and NR. Later on, Zaidi et al. (2019), explored a case study of 31 OECD economies, and found positive impact of growth on FD. Further, a case study related to Sub-Saharan Africa economies estimated the positive association of TO, FDI with economic growth due to strong institution (Asamoah et al. 2019). Similarly, Megbowon et al. (2019) measured the effect of OFDI of China on the Sub-Saharan Africa industrialization level, and explored the no significant imact in SSA. Guan et al. (2020) studied the effect of NR, GDP, human capital, and trade sector on FD in China, and the results explained the existence natural curse hypothesis. Redmond and Nasir (2020) studied the effect of NR abundance, FD, and trade on the economic development and showed the positive influence of NR on economic development. Likewise, trade and FD have a negative association with economic development.

2.2. Impact of Economic Development and its Determinants on Environment Quality

In the light of previous case studies, this section is divided into two different faces 1) deals with those studies, which try to estimate the impact of growth on carbon emissions, 2) deals with past studies, which attempted to evaluate the effect of growth on EFP. As a global issue, carbon emission and generally greenhouse gas emissions have been studied extensively from a different perspective. There has been much progress made in understanding the driving factors of carbon emissions. Zaman and Abd-el Moemen (2017) quantified the incidence of EKC-phenomenon and showed a positive association between emissions and energy consumption.

Similarly, there was a case study on different income groups showed the adverse effects of RE on GDP and CO_2, respectively (Bhattacharya et al. 2017), while this study ignores the inclusion of OFDI and NR. Likewise, Ciesielska and Kołtuniak (2017) estimated the effects of OFDI on

GDP, and supported the positive relationship between GDP and outward FDI. Another case study related to BRICS nations by Dong et al. (2017) supported the EKC-phenomenon and showed the negative association among NR, RE, and environmental quality (CO_2). Later on, Balsalobre-Lorente et al. (2018) applied the partial OLS for 5-EU countries and found the N-shaped linkage between GDP and emissions, while renewable electricity consumption was hurting carbon dioxide. Yi et al. (2018) used the Markov Switching-regression approach and found OFDI was increasing the level of emissions. Furthermore, Baloch et al. (2019) found the EKC hypothesis for all economies except India; also, they found the NR help in the reduction of CO_2. Jiang et al. (2020) found that the OFDI enhances emissions level, while ignored the NR. Likewise, several studies tried to estimate the Natural Curse Hypothesis [refers: Badeeb al. (2017); Ben-Salha et al. (2018); Adams et al. (2019); Xue et al. (2020)].

The second face tested the link between economic development with its determinants and EFP as a substitute for the environment. It is associated with the EKC, which recommends that the link between GDP and EFP is inverted and U-shaped. Charfeddine (2017) found the U-shaped EKC-hypothesis, while urbanization and TO hurt EFP. Similarly, in the same year Charfeddine and Mrabet (2017) found the EKC-hypothesis for oil and non-oil exporting MENA economies and this phenonmena also supported by Destek, et al. (2018) and Ulucak and Bilgili (2018). Besides, Zafar et al. (2019) estimated the long-run association among NR, human capital, FDI, and EFP, they found positive relation of human capital and NR with improved environmental quality except GDP and energy use. Later on, a case study related to Turkey by Sharif et al. (2020) found the RE reduces the ED. Likewise, several studies have tried to estimate the impact of development on EFP with its different determinants (Nathaniel and Khan 2020; Pata 2020; Nathaniel et al. 2020; Baz et al. 2020; Erdogan et al. 2020).

2.3. Criticism on past studies

It is imperative to note that previous literature has discussed the different types of socio-economic indicators such as energy use, fertility rate, life expectancy rate, FD, foreign direct investment, inflows, NR to quantify the effect on economic development or environment. There is no study on CEE-economies in the past literature, which tries to estimate the impact of achieved economic development with its determinants on environmental quality. OFDI is mainly neglected in the previous literature as a determinant of economic development and its impact on

environmental degradation, which may help the environment quality. So, there is a need to include such an exciting relationship to fill the gap of literature.

3. Data and methodology

This study used the yearly panel data for the period 1990-2017 for 16 selected CEE countries (Appendix Table 10). These selected economies decided to ratify both global and regional goals to enhance the proportion of RE consumption compared to non-RE consumption and reduce their level of pollution. For case in a point, selected countries devoted to lessening environmental pollution below 1990 by 2020, which is also the basis for the EU global obligations under the Kyoto protocol's scope. Based on the impacts above, we emphasize the countries whose RE pathway is critical for meeting worldwide and local climate and RE goals.

To examine the determinants of economic development such as OFDI, NR rents, FD, and RE consumption and their impact with achieved economic development on the environment. This study's key objective is to find the reasons why countries care about only development by ignoring the quality of the environment. To answer this question, raised empirical research undertakes the yearly data gathered from different sources. The data regarding economic development (income per capita), FD, and TO variables are sourced from the World Development Indicators (WDI) online source. The data for RE consumption, EFP, and OFDI variables are collected from the Knoema data bank. Table 1 summarizes the variables and their explanations, and Fig. 1 shows the scatterplot trend between economic development and other indicators.

Table 1: summary of the variables

Variables	Unit	Source
GDPC	GDP (US current $)/ total population	WDI
OFDI	Outward FDI (% GDP)	Knoema data source
NR	Natural resource rents (% of GDP)	WDI
FD	Domestic credit to private sector as % of GDP)	WDI
RE	RE consumption (% of total energy)	Knoema data source
EFP	Ecological footprint (global hectares per person)	Knoema data source
TO	Trade openness (US current $)	WDI

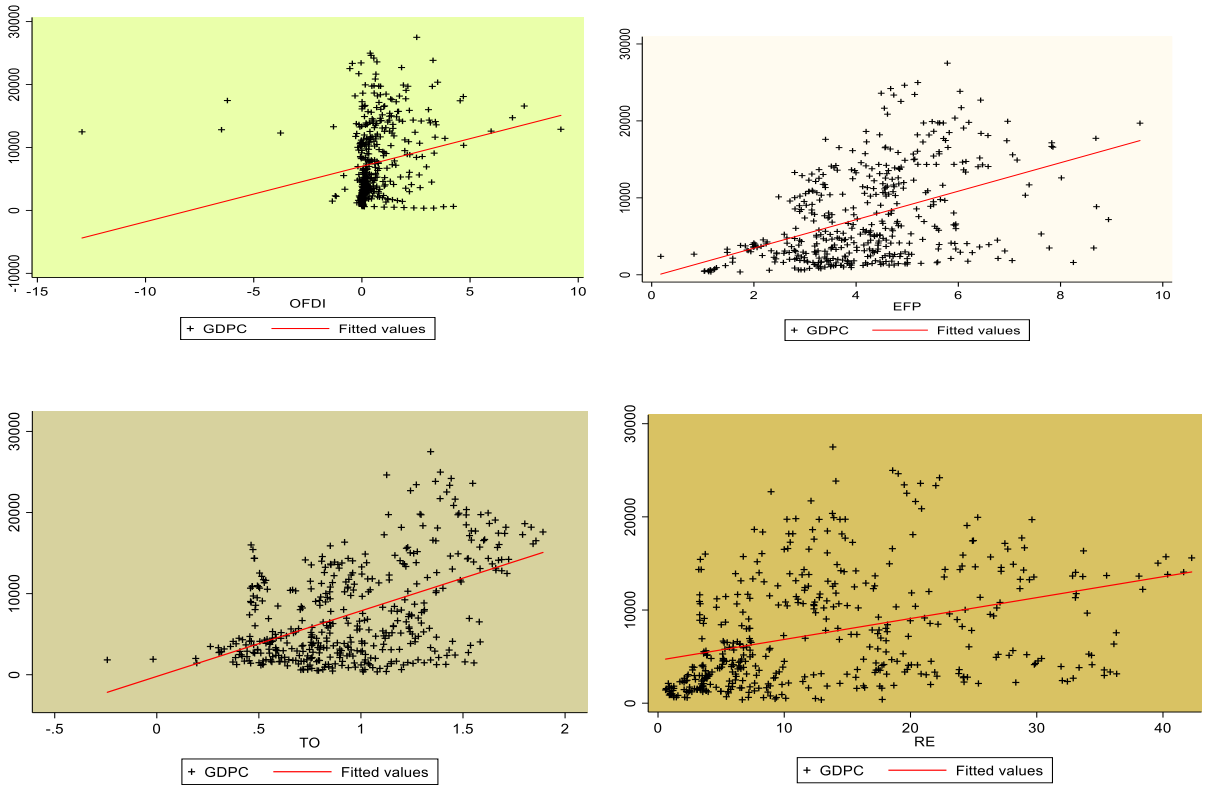

Fig. 1. Scatterplot trend between economic development and other indicators

In Table 2, correlation coefficients of the study variables are given. In the light of both models, the income per capita is positively correlated to EFP at the one percent statistical significance. The correlation matrix also discloses that LEFP is negatively correlated with OFDI, and likewise, this behavior with RE consumption at one percent level of significance. We also described a positive influence of TO on EFP at a one percent level of significance, while a negative correlation among NR, FD, and per person EFP variables is also statistically significant. Furthermore, OFDI, RE consumption, LFD, and TO have a positive correlation with income per capita, while NR income has a negative association at a 1% level of significance. According to the given correlation coefficient outcomes, there is no correlation among the variables as they have moderate values, and to confirm this, we have used the variance inflation factor (VIF) (see Appendix Table 11 for details).

Table 2: Matrix Correlation

	LEFP	LGPC	LOFDI	LRE	LTO	LNR	LFD
LEFP	1						
LGPC	0.4921307	1					

LOFDI	-0.216621	0.456482	1				
LRE	-0.016160	0.507268	0.2777223	1			
LTO	0.284128	0.361718	0.2384069	0.134772	1		
LNR	-0.174055	-0.27435	-0.054880	-0.34372	-0.231247	1	
LFD	-0.180013	0.333745	0.262324	0.223850	0.0405990	0.0961400	1

Model construction and Theoretical Background

To quantify whether the selected determinants of economic development contribute to the achieved economic development or not, and what is the effect of achieved economic development with its determinants on environmental quality in CEE economies, the following models are devised. For quantification drive, we have assumed the role of economic development, OFDI, NR, TO, FD, RE consumption, and EFP as a primary determinant of sustainability. In light of the previous discussion, this paper steps up two models to measure the linkage between economic development and environmental degradation (Equation 1).

$$LGDPC_{i,t}=\alpha_0+\alpha_1 LOFDIi_{,t}+\alpha_2 LNR_{i,t}+\alpha_3 LTO_{i,t}+\alpha_4 LFD_{i,t}+\alpha_5 LRE_{i,t}+\mu_{i,t} \quad (1)$$

Here, i and t denote the economy and time in the panel estimation, as i = 1, 2, …….., n and t = 1, 2, ……., T and μ is random error. The effect of OFDI and NR are determined by α_1 and α_2, respectively. Accordingly, statistically significant and positive α_3 directs that TO enhance the level of income per capita. The practitioner and policymakers have developed interesting scenarios since the last three decades between economic growth and environmental quality. Several studies have debated on economic growth and different proxies of environmental degradation, which covered different indicators for growth and environment situation (Brown and McDonough 2016; Pal and Mitra 2017; Kang et al. 2016).

This study extends the quadratic relationship with some interesting variables with an interaction term of economic development that may produce some interesting findings. This scene may raise the question of whether past policies are implemented efficiently. Evidence of the potential effect of achieved economic development with its determinants on environmental quality remained absent in the existing literature, and it suggests a new direction that needs to be introduced to policymakers. Achieved economic development may affect environmental quality with time. Previously scholars have developed two schools of thought regarding the role of growth in environment quality. Some studies support the evidence for a positive association between environmental degradation and economic development (Işık et al. 2019; Pata 2020; Halliru et al.

2020), while on the other hand, studies showed inverse effect among the said variables [refers: studies Dogan and Turkekul (2016); Aung et al. (2017); Yilanci and Pata (2020); Shah et al. (2020)]. Both groups of studies missed the concerned hypothesis. This study suggests that achieved economic development with its determinants may have a new direction for policymakers regarding environmental quality and development.

The vast body of literature has covered the relationship between economic development and environmental degradation proxies, and these studies have suggested various environmental regulations; however, these policies' implications and regulations seem ineffective in lowering environmental degradation. Diminishing effects can be tested by introducing interaction variables. The diminishing role is defined as the interaction of economic development variables with independent variables. To introduce the diminishing role of economic development with its determinants, we adopt interaction variables styled by Katircioğlu and Taşpinar (2017). Based on the above argument, the relationship between economic development and ecological footprint along with achieved economic development and its interaction with core variables is presented below (Equation 2).

$$LEFP_{i,t}=\beta_0+\beta_1 LGDPC_{i,t}+\beta_2 LGDP^2_{i,t}+\beta_3 LGDFD_{i,t}+\beta_4 LGDRE_{i,t}+\beta_5 LGDNR_{i,t}+\mu_{i,t} \quad (2)$$

Where, $LEFP_{i,t}$ of the ecological footprint of selected economies i at year t, economic development is measured by per capita income, LGDFD denotes the interaction variable of economic development and OFDI (LGDPC×LOFDI), LGDRE indicates the interaction term between renewable energy consumption and achieved economic development (LGDPC×LRE) and LGDNR is for achieved economic development and natural resource rents (LGDPC×LNR). Our analysis's contribution lies in introducing the interaction term of achieved economic development to control environmental degradation. Following, the above models, we aim to analyze the sensitivity of EKC and the natural curse or blessing hypothesis through numerous econometric specifications. The following section deliberates the assessment strategies implemented by the study.

3.1. Estimation Strategy

This study's baseline model is constructed on five steps as follows: the first step describes the CD test. Second is the unit root test to estimate the stationarity of the selected variables. The third step is about the estimation of cointegration panel estimation. The fourth step consists of long-run estimation techniques, and finally, the last step is the estimation of the causality relationship through Dumitrescu and Hurlin (D-H) Granger test.

3.2. CD tests

The basic step for estimation is to check the presence of CD. In the most recent empirical analysis, estimation of CD is the primary attention of all researchers, unlike the traditional panel techniques assuming the data as cross-sectional independence. The results obtained while ignoring the CD might lead to spurious quantification as most panel data influence each other.

Hence, three tests such as the CD test developed by Pesaran (2004), Friedman (1937), and Frees (1995), are used to finalize a plausible panel tool, though the mathematical forms of these CD ratio test can be elucidated as follows (Equation 3 to 5),

$$\text{CD} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right)N(0,1) \quad (3)$$

$$\text{FRI} = (j\text{-}1)\left[\frac{2}{N}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\gamma ij + 1\right]\ \chi 2\ (j\text{-}1) \quad (4)$$

$$\text{FRE} = \frac{(j-1)\left[\frac{2}{N}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\gamma ij + \frac{1}{j}\right]}{SE(Q)}\,N(0,1)i,j \quad (5)$$

The CD test has a drawback, such as lacking power under a situation where pair-wise correlations are zero. Therefore, to deal with this problem, Pesaran (2008) proposed the Lagrange Multiplier (LM) test by employing the mean and variance of Lagrange Multiplier (LM) statistics. The bias-adjusted LM statistics are given as Equation (6):

$$\text{LM}_{\text{adj}} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right)\left[\frac{(T-k)\hat{\rho}_{ij}^{2}-\mu\text{Tij}}{V(T-k)\hat{\rho}_{ij}^{2}}\right]\ \text{N}(0,1) \quad (6)$$

Where K is denoted as a regressor, and $\hat{\rho}_{ij}^{2}$ and μTij are the mean and variance. Similarly, to test the slope homogeneity, Pesaran and Yamagata (2008) suggested the delta test that is valid for (N, T) $\rightarrow \infty$ and its hypothesis could be stated as (Equation 7):

Ho : βi = βj

H1: βi ≠ βj

$$\Delta_{adj} = \sqrt{N}\left[\frac{N-1S - E(zit)}{\sqrt{V(zit)}}\right] \quad (7)$$

Cross-sectional dimension N could be relative to time (t), where $E(z_{it}) = k$ and $V(z_{it}) = 2k$ (T-k-1)/(T+1).

3.3. Panel units root test

To estimate the accurate outcomes, the first step is to observe the stationarity of factors. Widely accepted methods are often used, such as the Levin-Lin-Chu test by Levin et al. (2002) and Im, Pesaran and Shin (IPS) test by Im and Pesaran (2003), but the drawback of these test is that they cannot accounts for the CD, and rely on cross-sectional independence hypothesis. This study employs second-generation unit root tests, i.e., Covariate-Augmented Dickey-Fuller (CADF) and augmented cross-sectional IPS (CIPS), to avoid the problem of CD. The key feature of these tests is addressing the issues of CD and heterogeneity. The test statistics of CADF is expressed as Equation (8):

$$\Delta X_{it} = \Phi_i + \delta_i X_{i,t-1} + \gamma_i \bar{X}_{t-1} + \Psi_i \Delta \bar{X}_t + \mu_{it} \quad (8)$$

Where $\bar{X}_{t-1}$ represents the mean across each cross-section. Further, the CIPS test can be presented as given in Equation (9):

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} \delta_i\,(N,T) \quad (9)$$

3.4. Panel cointegration tests

After checking the stationarity of variables, the long-run association between variables can be identified by putting on an error correction-based test (Westerlund and statistics 2007). Unlike traditional cointegration techniques, this test accounts for heterogeneity and autocorrelation and includes the stochastic shocks due to unobserved factors in panel data that simple methods cannot do. The dependency results might be weak or strong, but if ignored, they lead to inappropriate estimates. The cross-sectional error could result from common shock, spatial effects, and omitted common effects that can add *n* error term. The practical form of Westerlund cointegration can be expressed as Equation (10):

$$\Delta Y_{it} = \delta'_i d_t + \eta_i\left(Y_{i,t-1} - \beta'_i x_{i,t-1}\right) + \sum_{j=1}^{p_i} \eta_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta x_{i,t-j} + \mu_{it} \quad (10)$$

Where $\delta'_i d_t$ and η_i are the deterministic and coefficient of error correction terms. This test is based on two statistics, i.e., group (G_τ, G_a) and panel (P_τ, P_a). The null and alternate hypothesis can be expressed as:

$H_o : \delta_i = 0$

$H_1: \delta_i = \delta < 0$ (for all *i*)

The rejection of H_o means all the panel is cointegrated.

3.5. AMG and CCE-MG econometric techniques

The cointegration presence is the symbol to proceed to the next step of estimation, i.e., long-run relations between the variables. In this regard, we used the two-panel estimation technique to check the long-run association.

Phillips and Sul (2007) recommended that when models agonize from the CD, heteroskedasticity, and serial correlation, panel estimators, can mislead inferior and even inconsistent estimators. To remove these problems, Pesaran has recommended the Common Correlated Effects, which are further developed by Kapetanios et al. (2011) and Chudik et al. (2011). This approach has numerous advantages associated with the first-generation econometric methods; it does not contain the approximation of unobserved common factors and factor loading (Pesaran 2007). In this stage, our study will use the AMG algorithm proposed by Bond and Eberhardt (2013) and Dong et al. (2018). AMG is flexible and without limitation of non-stationary variables in the calculation (Destek and Sarkodie 2019). The study also uses the CCE-MG estimator (Pesaran 2007) to calculate the long-run estimate that accounts for the CD. The CCE-MG method is robust in reducing a limited number of solid features and an infinite number of weak attributes (Eberhardt 2012). Further, to estimate the casual linkages among variable have estimated by Dumitrescu and Hurlin (2012).

4. Results and discussion

In this section, the empirical results of the relationship between economic development and environmental quality are given for CEE economies for two different empirical models as

described above. Thus, for the empirical analysis, descriptive statistics plays an important role.

Descriptive statistics

The following Table 3 gives descriptive statistics of the variable for the selected panel under inquiry. Table 3 depicts no significant difference between the mean and median of all concern factors, and all variables show a considerable extent of attention.

Table 3: Descriptive Statistics

	LEFP	LGPC	LOFDI	LTO	LRE	LNR	LFD
Mean	0.59058	3.71383	-0.66712	-0.05365	0.96723	0.02261	1.78547
Median	0.62278	3.72288	-0.59850	-0.03631	1.00920	0.01771	1.84876
Max.	0.98018	4.43936	1.11181	0.27687	1.62607	1.33625	2.60982
Mini.	-0.74928	2.55291	-4.57017	-0.71927	-0.22142	-1.10823	0.06240
Std. dev.	0.17874	0.41184	0.83501	0.18347	0.39102	0.48117	0.38969
Skewness	-1.72665	-0.42127	-0.73514	-0.52115	-0.55888	0.41731	-0.94789
Kurtosis	10.8293	2.43330	4.18230	2.91674	2.85740	3.06154	4.47371
J-Bera	1357.70	19.1168	66.0004	20.2721	23.5429	12.9865	106.908
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.0000

4.1. CD of the selected variable

Here, the findings of the CD tests are provided. Findings of CD tests have been given in Table 4. Results validate early perceptions since the different techniques assumed can strongly reject H_0 of cross-sectional independence for both panels. As a result, our specific income groups showed CD, and thus, 2nd generation unit root and cointegration tests that accommodate the dependence problem are applied to attain consistent findings. In addition, findings of the test for homogeneity are given in Table 5.

Table 4: CD tests

	Model 1		Model 2	
	Value	P-value	Value	P-value
LGDPC = f (LOFDI, LNR, LTO, LFD, LRE)			LEFP = f (LGDPC, $LGDPC^2$, LGDFD, LGDRE, LGDNR)	
Pearson (CD)	19.153	0.000	5.112	0.000
Frees (Q)	3.273	0.005	2.701	0.005
Friedman (CD)	166.788	0.000	82.282	0.000

Table 5: Test for Homogeneity

Model 1: LGDPC = f (LOFDI, LNR, LTO, LFD, LRE)				LEFP = f (LGDPC, LGDPC^2, LGDFD, LGDRE, LGDNR)		
	Delta	adj.		Delta	adj.	
Statistics (P- value)	7.525 (0.000)	8.532 (0.000)		7.976 (0.000)	9.044 (0.000)	
Dependent Variable	LM	LM adj*	LM CD*	LM	LM adj*	LM CD*
Statistics (P-value)	231.4 (0.000)	13.6 (0.000)	1.566 (0.001)	232.4 (0.000)	13.78 (0.000)	1.455 (0.145)

4.2. Second-generation unit root tests

Comprehensive findings of the panel unit root tests for both panels are presented here in Table 6. For the specific panels, the CIPS test results expose that LGDPC, LOFDI, LFD, LRE and LTO are stationary at the first difference, while NR and EFP are stationary at the level. The results of CIPS are also occupied with CADF test in the concerned countries.

Table 6: Findings of CIPS and CADF tests

Variables	CADF		CIPS	
	Level	1st diff.	Level	1st diff.
LGDPC	-1.114	-3.992***	-1.114	-3.458***
LOFDI	-1.583	-2.758***	-1.567	-2.999***
LNR	-2.184**	-5.157	-2.184**	-3.251
LFD	-1.222	-3.876***	-1.564	-3.946***
LRE	-1.436	-4.740***	-1.498	-3.478***
LTO	-1.134	-3.852***	-1.524	-3.996***
LEFP	-3.237***	-5.350	-3.278***	-3.661

Note: *** and ** represent the one and five percent significance level.

4.3. Westerlund panel cointegration tests

Cointegration association between the variables in models 1 and 2 by following the (Westerlund and statistics 2007) error correction model cointegration method are provided in Table 7. This cointegration test is in line with our selected data since it permits for the CD. Table 7 represents the result of the cointegration by comprising constant and trend as it can be seen from both models. G_t and P_t test statistics reject the H_0 of no cointegration with bootstrapped P-values at one and five percent statistical significance. Such as, the cointegration vectors are conformed for

both models. Study results depict the cointegration association between all concerned factors, as explained in the models of study.

Table 7: Findings of Westerlund cointegration technique

Statistic	Value	Z-value	P-value	Robust P-value
	LGDPC = f (LOFDI, LNR, LTO, LFD, LRE)			
Gt	-9.826	7.212	1.000	0.008
Ga	-2.451	8.363	1.000	0.254
Pt	-2.908	8.269	1.000	0.900
Pa	-12.997	6.910	0.056	0.000
	LEFP = f (LGDPC, $LGDPC^2$, LGDFD, LGDRE, LGDNR)			
Gt	-9.931	-3.981	0.000	0.001
Ga	-0.251	8.254	1.000	0.975
Pt	-4.549	6.622	1.000	0.053
Pa	-0.361	6.793	1.000	0.768

4.4. AMG and CCE-MG estimation outcomes

In this sub-section, findings of the AMG and CCE-MG approaches are given for both models for the CEE economies. Discussion of analysis is given in two parts for both models separately.

4.4.1. The long-run impact of selected macroeconomic variables on economic development

Table 8 provides the AMG and CCE-MG regressions results for the selected explanatory variables on the economic development (per capita income) for the CEE economies. We start by debating the findings of concerned economies under both econometric specifications, i.e., AMG and CCE-MG for the first model. The outcomes attained exhibited that OFDI has s significant and positive influence on economic development. In the CEE economies, it is clear that the liaison between economic development and OFDI is positive. This shows that any action to progress OFDI has a significant positive impact on per capita income. Likewise, a 1% rise in this factor causes a rise in economic development by 0.4107% and 0.6517% at one percent level. Thus our findings are coherent with a case study of Sub-Saharan Africa by Obobisa (2019); another case study to BRICS economies also supports the positive association (Mohanty and Sethi 2019). Likewise, according to regression results, economic development and OFDI have a significant positive association with each other; the empirical investigation by Zhang (2013) by

employing the Solow model found the same results. This means that CEE economies' OFDI is conducive to encouraging the concerned economies' economic development.

Regarding the factors of economic development, as one would expect, the coefficient of NR income is a positive and highly significant impact indicating that NR has a growing effect on the economic development under both specifications (AMG and CCE-MG). Alternatively, a one percent rise in this factor (NR) would cause to augment the economic development by 0.9230% and 0.1217%, respectively. This makes it clear that an abundant NR has a positive effect on economic development. Seemingly, rich and high-quality NR can deliver security for sustainable and stable economic development. In contrast with resource-poor states, countries with strong NR have a better foundation for economic growth and can generate resources more rapidly. They are best suited to cross-domain growth when synchronized with organizations, resources, and other components. These results support the resource bless and go consistent with existing literature, including Ben-Salha et al. (2018) and Wei et al. (2020).

Likewise, the positive impact of NR on economic development suggests that NR is a blessing for GDP in the top resource's abundant economies. It aids in generating jobs that are more decent, stimulating investment, and increasing FD. Besides, a positive relationship between NR and GDPC suggests the rise of GDPC may incite governments to heighten their expenditure on the exploration and extraction of NR, increasing the NR revenues in the long-run. In the same way, higher economic growth levels are believed to help improve local infrastructure and then increase domestic and international investments for exploration and extraction in the NR sector.

Regarding the other determinants of economic development, TO has a statistically noteworthy and positive association with economic development for the panel of specified economies. One percent increase in TO increases the GDPC around 0.1849% under the AMG specification and nearly 0.2288% under CCE-MG specification. These outcomes are concurrent with Nigeria and Ghana's case study by Khobai et al. (2018) and another study of China by Kong et al. (2020). In other words, TO shows a significant effect on economic development, endorsing the trade-induced growth hypothesis. Our findings support the prevailing literature and empirical confirmation presented by a case study of SADC nations by Maune (2019), a study related to Turkey by (Alsamara, Mrabet et al. 2019), and a study of BRICS economies by Rani and Kumar

(2019). Likewise, some studies contrasted with our findings, such as Olaifa et al. (2013) and Khobai et al. (2018).

Similarly, FD is considered as another determinant for economic development. A one percent increase in FD would cause to rise in economic development by 0.029% and 0.0717% under both specifications. An upsurge in FD plays a vital role in long-run economic development. If an easy monetary policy is pursued by the central bank, which corresponds to a higher inflation scenario, commercial banks are asked to increase the borrowing cost in terms of interest rate on both consumer and producer loans. Such orthodox tight monetary policy lowers the level of debt given to the economy's different sectors. This clarification also shows that a negative shock in banking sector growth will create predictable rationality for customers and investors, thereby restricting further credit expansion. Therefore, the potential development of loans issued by the banking sector appears to be even more vigilant. This boosts actual economic development and growth.Our findings are in support of a study of middle-income economies by Yang (2019), another study related to Next-11 economies by Erdoğan et al. (2020).

The last indicator of economic development in the first model is RE consumption. From the results of AMG and CCE-MG, it is clear that the coefficient (0.3911 and 0.2997) of RE consumption has a positive link with the GDPC which shows that a one percent increase in this factor (RE) would increase economic development by 0.3911% and 0.2997% under both specifications. If per capita income crosses the threshold value, the RE demand increase has a more favorable economic growth effect. In realistic terms, higher per capita income is necessary to stimulate technical progress, boost productivity, and enhance innovation potential for a country's research, development, and educational expenditure. Simultaneously, high-tech, foreign capital, and talent inflows can be readily drawn to bring benefits from the advancement of RE technology and encourage technology reforms and energy efficiency. As a result, the buoyant weight of promoting RE usage on economic development is more significant. These results are concurrent with relevant available literature such as by Destek and Aslan (2017), Adams et al. (2018), Charfeddine and Kahia (2019), Bao and Xu (2019), and Dogan et al. (2020).

Table 8: Long run results of AMG and CCE-MG estimators

	AMG	CCE-MG

	Coef.	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|
	Wald chi^2 [19.17 (0.000)]			Wald chi^2 [43.58 (0.000)]		
	LGDPC = f (LOFDI, LNR, LTO, LFD, LRE)					
LOFDI	0.4107	.01225	0.037	0.6517	0.3174	0.000
LNR	0.9230	0.0280	0.000	0.1217	0.0356	0.001
LTO	0.1849	0.0744	0.000	0.2288	0.0968	0.018
LFD	0.0209	0.4756	0.001	0.0717	0.0554	0.006
LRE	0.3911	0.0830	0.005	0.2997	0.1100	0.000
Cons.	3.2385	0.12941	0.000	-1.0053	0.1773	0.000
	LEFP = f (LGDPC, LGDPC^2, LGDFD, LGDRE, LGDNR)					
	Wald chi^2 [34.13 (0.000)]			Wald chi^2 [48.28 (0.000)]		
LGDPC	1.1690	1.6600	0.001	3.2752	1.6809	0.051
LGDPC^2	-.72780	.21003	0.000	-.34634	.22067	0.007
LGDFD	-.002692	.00162	0.006	-.00541	.00282	0.055
LGDRE	-.041029	.01580	0.000	-.04635	.04092	0.000
LGDNR	-.014941	.01032	0.022	-.06754	.04168	0.001
Cons.	--2.5318	3.2695	0.039	-6.5770	2.6191	0.012

4.4.2. Impact of determinants of economic development (achieved) on environment quality

The second panel of Table 8 represents the estimations through AMG and CCE-MG to achieve economic development on environmental quality. Likewise, in the second model, the EFP is taken as the dependent variable to estimate environmental degradation due to attainable economic development with the interaction terms of LGDFD, LGDRE consumption and LGDNR. For understanding the effect of economic development on environmental degradation, we have used income per capita as a proxy for achieved economic development. To answer this question raised at the start of the study, we have taken help from Environment Kuznets curve hypothesis theory, which is well known. For the understanding of EKC-hypothesis, the GDPC^2 is introduced for the EFP.

Likewise, the co-efficient of GDPC ($\beta_1 > 0$) and the GDPC^2 ($\beta_2 < 0$) recommended that one percent increase in this factor can cause an escalation of 1.169% in the dependent variable while the square of GDPC can cause a reduction of 0.7278% in the EFP for the AMG-specification. A one percent increase in concern factors [GDPC and GDPC^2] would lead to an increase of 3.275% and a decrease of 0.346% in the EFP, respectively, for CCE-MG. In other words, in the early phases of growth, income levels increase the environmental destruction and decrease as income reaches a turning point. (Sarkodie 2018) explained that a decrease in environmental degradation

versus economic development could be due to a structural variation in GDP and technological encroachment. As the income level increases, environment cognizance rises, thus driving the population to demand a clean environment causing the enforcement of environmental laws, policies, and regulations, which reduces environmental degradation (Sarkodie and Strezov 2019). Thus, such kind of association between development and EFP shows that economic development is a guarantee to achieve clean environment in selected economies. These findings confirm inverted U-shaped EKC-hypothesis and are coherent with the existing studies, such as a case study related to 31 provinces of China (Li et al. 2016), analysis related to the USA also support the evidence of inverted U-shaped EKC (Aslan et al. 2018), same is suggested by Shahbaz et al. (2019) and a case study of 50 top tourist economies also showed same results (Fethi and Senyucel 2020).

Interaction variables LGDFD has a negative link with EFP under the specifications of AMG and CCE-MG. Alternatively, a one percent rise in this variable would decrease the level of environmental degradation by 0.0026% (AMG) and 0.0054% (CCE-MG), respectively. In other words, raising the level of LGDFD will decrease environmental degradation in concerned economies, which demonstrates the presence of LGDFD reverses the technology overflow. Domestic firms have reduced their use of resources by consuming international businesses' innovative manufacturing technologies after expanding foreign direct investment. These outcomes are consistent with the prevailing literature, which tried to estimate the association between OFDI and environmental degradation, such as by Kan and Huang (2019), Xin and Zhang (2020), and Ding et al. (2017).

The interaction variable LGDRE's effect on environmental degradation is negative and statistically significant at one percent level of significance under both econometric techniques. It is noted that a one percent rise in LGDRE consumption leads to a 0.0410% and 0.0463% decrease in the level of environmental degradation for the CEE economies. By way of explanation, the empirical findings of this study propose that the incorporation of RE technologies in the CEE economies energy mix upgrades the environment quality. The reason was perceptible to burnable waste in RE consumption reconnoitered; however, this indicator was pronounced to emit less environmental degradation compared to non-RE use. That is why our findings support the recent environment policy thrust of nations across the world as fine-turned

by the Kyoto Protocol arrangements and the inter-governmental panel on climate variations. These findings are also supported by several existing studies (Ulucak and Khan 2020; Naqvi et al. 2020; Destek and Sinha 2020; Altıntaş and Kassouri 2020).

The coefficient of interaction term LGDNR concerning EFP is -0.0149 and -0.0675, respectively, for both specifications. The results infer that LGDNR significantly and negatively affects the level of environmental degradation. This shows that a decrease in environmental degradation equivalent to 0.0149% and 0.0675% is due to a one percent increase in LGDNR. The positive role of LGDNR in sustainable environmental degradation is combined with consumption and production, the rate of depletion, and environmental stress reduction, thus cause LGDNR to regenerate. Moreover, as natural resource exploitation moves from an obsolete technology to technology that combines recycling, manufacturing, creativity, value change, and artificial resource replacement, NR growth will be driven economically and boost environmental sustainability (Bekun et al . 2019). The abundance of NR decreases reliance on fossil fuel imports, and NR abundance is adequate to satisfy energy demands and, ultimately, environmental pollution can be minimized. These results are consistent with existing literature like Zafar et al. (2019) and Ulucak and Khan (2020).

4.5. D-H panel causality test

Along with the long-run connotation between models' variables, it is vital to explore the causal relations among them. This paper uses a newly developed pair-wise D-H panel causality test proposed by Dumitrescu and Hurlin (2012). It is the advanced version of the Granger non-causality method for the panel data. Also, this tool includes two statistics, such as W-bar and Z-bar statistics. Thus W-bar statistics yield the average test statistics, while the standard normal distribution is embodied by the Z-bar statistics (Dumitrescu and Hurlin 2012). Lastly, the track of causality will help policymakers standardize suitable economic policies and economic approaches in the selected economies.

4.5.1. The causal association between economic development and its factors

The D-H panel causality test outcomes are provided in the following Table 9. This table is divided into six columns; the first three columns A, B, and C are for the first model, while D, E, and F are for the second model as before explained in detail. In the first model, the long-run two-

546 way causality feedback exists between economic development and TO. The directional of
547 causality shows TO causes the change in economic development, and improvement in the
548 LGDPC causes TO. The findings support the feedback hypothesis, which means that economic
549 development in selected economies strongly correlates with TO. Also, any change in economic
550 development will positively affect the trade sector in CEE economies and vice versa. TO causes
551 the finding of economic growth, and vice versa supports the trade-led growth hypothesis in the
552 case of specified economies. These findings are in line with the previous case study South Africa
553 by Shakouri and Khoshnevis Yazdi (2017). Likewise, the casual results in light of the first model
554 also support the bidirectional causality between RE and economic development. This means that
555 any fluctuation in LRE replicates the economic development immediately, while LGDPC
556 stimulates RE in the long run.

557 Furthermore, the incidence of feedback hypothesis between RE and economic development
558 provides their mutual interdependence, which increases the usage of LRE and positively impacts
559 economic activities. The RE sector's advancement is suitable due to its positive effect on
560 declining the level of environmental degradation and helping out in sustainable development
561 (Apergis and Payne 2012). Similarly, the outcomes also support the two-way causal association
562 between FD and OFDI, which means policies relevant to FD and outward FDI work jointly.
563 Thus all concerned policies applicable to FD and OFDI should be efficient in the long run. Also,
564 there has been a bi-directional causality relationship between TO and NR, and these results
565 support a case study of OECD economies by Zaidi et al. (2019). Further, results showed a bi-
566 directional relationship from FD and RE consumption to TO and FD to RE consumption in
567 specified economies. Above and beyond, unidirectional causality was deducted from income per
568 capita to outward FDI, NR, and FD, and from TO to outward FDI.

569 ***4.5.2. The casual relationship among achieved economic development, its determinants***
570 ***and EFP***

571 In Table 9, columns D, E and F are related to the second model when EFP is considered a proxy
572 of environmental degradation. The D-H test findings reveal that there is two-way causality
573 between the LGDNR and LEFP. The results expose that any change in LGDNR will cause a
574 change in environmental degradation. In addition, feedback relation exists from LEFP to
575 LGDNR, which shows that a variation in environmental degradation can have a considerable

576 effect on LGDNR. Overdependence on NR triggers the level of environmental degradation in an
577 NR-dependent economy. Diversification, and structural variation in economic development are
578 needed to attain sustainable development.

579 Similarly, the results indicate that LGDRE consumption can significantly cause variation in the
580 level of environmental degradation in the selected CEE economies. In contrast, the feedback
581 relationship from LEFP to LGDRE consumption shows that any fluctuation in the environmental
582 degradation will affect the LGDRE. Further, Granger causality results suggest a bi-directional
583 causal association between LGDRE consumption and LGDNR, which means that policies
584 relevant to LGDRE and LGDNR are working jointly. Finally, unidirectional causality is
585 deducted from economic development and its square to LEFP, LEFP to LGDFD, LGDPC to
586 LGDFD, economic development to LGDRE and LGDNR. The graphical representation for both
587 models is given in appendix Fig. 2.

588 ***Table 9: D-H panel causality test***

	Model 1			Model 2			
	A	B	C		D	E	F
Null Hypothesis	W-Stat	Z-bar Stat.	Prob.	Null Hypothesis	W-Stat	Z-bar Stat.	Prob.
LOFDI ≫ LGDPC	3.04823	1.36385	0.172	LGDPC ≫ LEFP	6.15349	6.41951	0.000
LGDPC ≫ LOFDI	4.59556	3.88306	0.000	LEFP ≫ LGDPC	2.90639	1.13292	0.257
LNR ≫ LGDPC	2.03251	-0.28983	0.771	$LGDPC^2$ ≫ LEFP	5.65196	5.60298	0.000
LGDPC ≫ LNR	5.71773	5.71006	0.000	LEFP ≫ $LGDPC^2$	2.63590	0.69255	0.586
LTO ≫ LGDPC	2.78874	0.93744	0.000	LGDOF ≫ LEFP	2.35106	0.22879	0.819
LGDPC ≫ LTO	7.97958	9.37584	0.000	LEFP ≫ LGDOF	4.20019	3.23935	0.001
LFD ≫ LGDPC	2.42547	0.34851	0.727	LGDRE ≫ LEFP	4.31513	3.42649	0.000
LGDPC ≫ LFD	11.2462	14.6994	0.000	LEFP ≫ LGDRE	3.74524	2.49866	0.012
LRE ≫ LGDPC	3.24345	1.68170	0.000	LGDNR ≫ LEFP	4.49715	3.72283	0.000
LGDPC ≫ LRE	5.74711	5.75789	0.000	LEFP ≫ LGDNR	6.17921	6.46138	0.000
LNR ≫ LOFDI	1.78002	-0.70091	0.483	LGDPC ≫ $LGDPC^2$	5.10366	4.71029	0.000
LOFDI ≫ LNR	1.68547	-0.85484	0.392	$LGDPC^2$ ≫ LGDPC	5.45320	5.27938	0.000
LTO ≫ LOFDI	5.01490	4.55636	0.000	LGDFD ≫ LGDPC	2.87174	1.07652	0.281
LOFDI ≫ LTO	1.58946	-1.01214	0.311	LGDPC ≫ LGDFD	4.23946	3.30329	0.001
LFD ≫ LOFDI	3.70654	2.43274	0.015	LGDRE ≫ LGDPC	2.99554	1.27808	0.201
LOFDI ≫ LFD	3.69370	2.41185	0.000	LGDPC ≫ LGDRE	8.47357	10.1968	0.000
LRE ≫ LOFDI	2.82960	1.00791	0.313	LGDNR ≫ LGDPC	2.03251	-0.28983	0.771
LOFDI ≫ LRE	2.09469	-0.18860	0.850	LGDPC ≫ LGDNR	5.23665	4.92681	0.000
LTO ≫ LNR	4.88475	4.34479	0.000	LGDFD ≫ $LGDPC^2$	2.90932	1.13770	0.255
LNR ≫ LTO	3.95379	2.83138	0.004	$LGDPC^2$ ≫ LGDFD	4.18456	3.21391	0.001
LFD ≫ LNR	2.67935	0.76156	0.446	LGDRE ≫ $LGDPC^2$	2.88343	1.09554	0.273
LNR ≫ LFD	4.79228	4.19917	0.000	$LGDPC^2$ ≫ LGDRE	8.51987	10.2722	0.000
LRE ≫ LNR	3.61413	2.28519	0.022	LGDNR ≫ $LGDPC^2$	1.63252	-0.94105	0.364
LNR ≫ LRE	3.38977	1.91992	0.054	$LGDPC^2$ ≫ LGDNR	1.70616	-0.82116	0.411
LFD ≫ LTO	6.08131	6.28433	0.000	LGDRE ≫ LGDFD	2.72991	0.84561	0.397

LTO ≫ LFD	4.64863	3.95695	0.000	LGDFD ≫ LGDRE	2.66702	0.74321	0346
LRE ≫ LTO	5.40953	5.19788	0.000	LGDNR ≫ LGDFD	1.63252	-0.94105	0.483
LTO ≫ LRE	3.72272	2.45576	0.014	LGDFD ≫ LGDNR	1.70616	-0.82116	0.411
LRE ≫ LFD	3.53500	2.15366	0.031	LGDNR ≫ LGDRE	3.26913	1.72350	0.004
LFD ≫ LRE	5.94303	6.07137	0.000	LGDRE ≫ LGDNR	4.01877	2.94399	0.003

5. Conclusions and policy recommendations

Key focus of this paper is to estimate the critical determinants of economic development (achieved) and its impacts on environmental degradation in CEE economies for the time of 1990-2017 with annual frequency. The study firstly checks out the CD across the panel and applies the second-generation panel unit root tests that consider CD accordingly. Based on the Westerlund cointegration association study's endorsement, it executes AMG and CCE-MG estimators, which yields a long-run relationship among indicators. Results found a positive relationship between explained (LGDPC) and explanatory variables (LOFDI, LTO, LFD LRE and LNR) in the light of the first model. Thus, all determinants of economic development showed that they help to boost economic development in CEE economies.

We have developed another model containing economic development and its determinants, such as interaction terms of economic development with OFDI, NR, and RE consumption, which can influence the environment. An inverted U-shaped association is found between the per capita income and LEFP. Thus, achieved economic development is a guarantee for sustainable development in CEE economies. Likewise, LGDNR, LGDFD, and LGDRE consumption reduce environmental degradation. In the end, the D-H panel causality test explores the nature of the relationship among study variables. Similarly, in the first model, there is bidirectional causality between economic development and TO. Also, GDPC and RE consumption Granger cause each other.

Furthermore, the feedback hypothesis is found between FD and OFDI, TO and NR income, RE and NR income, FD and TO, RE and TO, and FD and RE consumption. However, one-way causality is running from per capita income to OFDI, NR, and FD. Finally, TO Granger causes OFDI. In the case of the second model, there exists a two-way causality between LGDNR and environmental degradation. LGDRE usage and LEFP, Granger, causes each other. A feedback hypothesis is found between LGDRE consumption and LGDNR. Likewise, unidirectional

causality is running from economic development to environmental degradation, from LEFP to LGDFD, and from LGDPC to LGDFD. In the last LGDPC, Granger causes interaction term of LGDNR.

The investigated results give some practical implications that may be imperative for policy inferences. First, attention should be given to the interaction term of LGDFD in terms of the industrial sector. The explicit requirements include the following main points. The proportion of host economies technology seeking LGDFD should be enhanced. In the light of empirical findings, a one percent rise in LGDFD will decrease environmental degradation equal to 0.0026% and 0.0056% for both specifications (AMG and CCE-MG), implying that in CEE economies, LGDFD can produce an adverse outcome on environmental degradation. Therefore, the purpose of low environmental degradation in CEE economies can be attained by regulating outward foreign direct investment industry selection and increasing the proportion of technology seeking outward foreign direct investment industry. The government must build favorable political support and a legal climate for industries to attract competitive companies internationally in foreign fields such as clean energies, new technologies, and new manufacturing. By converting domestic surplus potential and extending the overseas market, it can reverse the technology spillover impact of OFDI.

Regarding LGDRE consumption, this factor plays an imperative role in reducing the level of environmental degradation. The inclusion of RE consumption at a higher rate in the energy mix is recommended. When revenue grows, more budget is to be earmarked for RE-project developments. On the other side, economic development can alone control pollution coupled with some strict environmental measures required to ensure more sustainable NR use. Likewise, in light of selected economies, the policymakers are suggested to increase the share of RE in their energy mix to manage their NR efficiently and control their globalization pattern similar to their current implications to establish a sustainable future. The EFP, with the increasing economic growth, is an opportunity for the policymaker to spend further on RE development as the energy sector is directly linked to three pillars of sustainable development (Ulucak et al. 2019).

This study has some limitations to a certain degree. First, it emphasizes the effect of achieved economic development with its determinants on environmental degradation by using EFP, in

CEE economies, with limited possibilities to look at the impact of inward FDI and another form of RE such as nuclear energy, biomass energy on economic development by HDI and environmental degradation by SO_2, carbon footprint. Furthermore, this paper only deliberates the selected inducing factors of geographical and development level in the analysis of heterogeneity, but several other factors may affect the economic development and environmental quality and can be considered by future studies.

Ethical Approval and consent to participate

Not applicable

Consent for publication

Not applicable

Author Contribution

Qianxiao Zhang: Conceptualization, Methodology, Editing original draft, **Syed Ale Raza Shah:** Conceptualization, Methodology, Software, **Syed Asif Ali Naqvi:** Writing - original draft, Writing - review & editing.

Funding

There is no financial support for this work that can influence its outcome.

Competing Interests

The authors declare that they have no competing interests.

Data Availability and Materials

The data will provide the corresponding author on demand.

Acknowledgments

The authors are very grateful to all those who provided help during this research.

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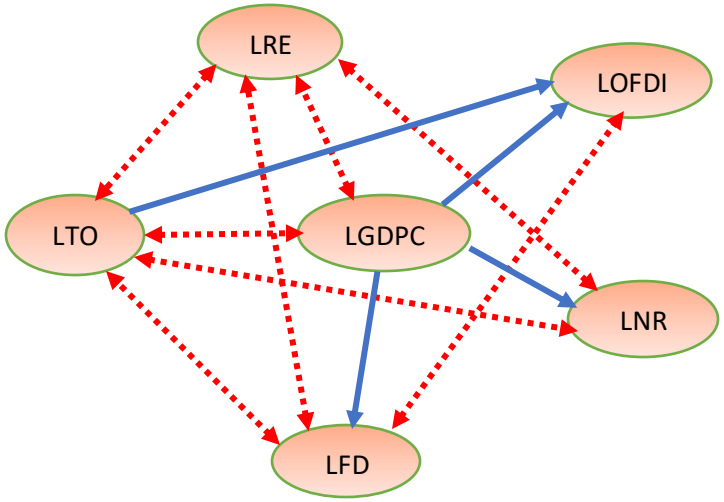
Appendix

Table 10 List of selected CEE economies

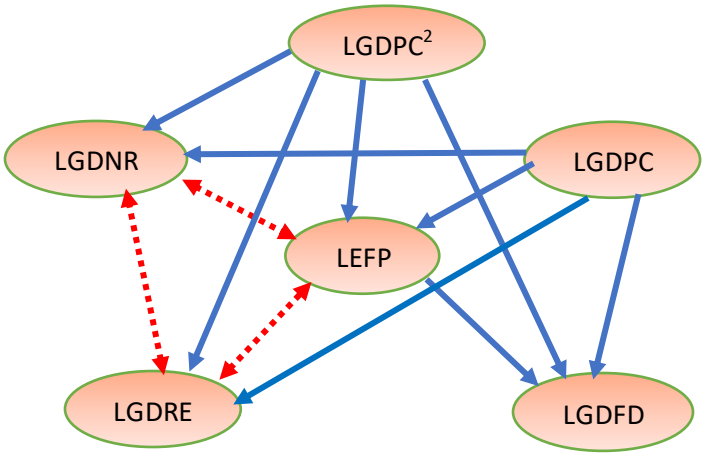
Selected Region	Name of Countries
CEE Economies	Armenia, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovak Republic, Slovenia, Turkey, Ukraine,

Table 11 Variance inflating factors

Variable	VIF	1/VIF
	Model 1	
LRE	1.29	0.776400
LNR	1.23	0.812666
LOFDI	1.19	0.838287
LFD	1.14	0.875803
LTO	1.12	0.895399
	Model 2	
LGDPC	3.37	0.296735
$LGDP^2$	4.91	0.203665
LGDFD	1.28	0.778335
LGDNR	1.30	0.769913
LGDRE	1.95	0.513987



(i) Causal linkage of achieved economic development with its determinants



(ii) Causal linkage of economic development and ecological footprint

Note: Unidirectional ⟶ and Bidirectional causality ⟷

Fig. 2 Causal linkage of achieved economic development with its determinants