sciendo
STUDIA UNIVERSITATIS ECONOMICS SERIES
"Vasile Goldiş" Western University of Arad
SUES
2024 - 34(3) DOI: 10.2478/sues-2024-0015

ECONOMIC COMPLEXITY AS A DETERMINANT OF GREEN DEVELOPMENT IN THE CENTRAL AND EASTERN EUROPEAN (CEE) COUNTRIES

Olimpia Neagu*
"Vasile Goldiş" Western University of Arad, Romania
University of Oradea, Romania
Romanian Academy of Scientists, Bucharest, Romania
E-mail: neagu.olimpia@uvvg.ro

Mădălin-Ioan Neagu
Technical University of Cluj-Napoca, Romania
E-mail: madalin.neagu@cs.utcluj.ro

(Received: October 2023; Accepted: December 2023; Published: July 2024)

Abstract: The paper analyses the determinants of green development in the Central and Eastern European (CEE) countries pointing out the influence of the sophistication of productive structure and exported goods (economic complexity). The study uses OECD data regarding green development, World Bank Indicators, World Penn Table Data, and MIT Harvard data covering the period of 1996 to 2020, in a heterogeneous panel approach. Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) models are estimated in order to express the influence on green development of the economic complexity index, KOF globalization index, renewable energy consumption, human capital index, and a constructed institutional quality index (computed by using the Principal Component Analysis based on data from World Governance Indicators). All considered variables have a validated statistical influence on green growth in both models. The Dumitrescu-Hurlin causality test revealed a bidirectional causal relationship between institutional quality and green growth and unidirectional ones from economic complexity, human capital and renewable energy to green development and from green development to globalization. Policy implications are also provided.

Keywords: green growth; economic complexity; globalization; human capital; renewable energy; panel data.

JEL Codes: C23, F64, J24, O10, O 24, O43, 044, Q51.

* Corresponding author: Olimpia Neagu. *E-mail: neagu.olimpia@uvvg.ro*

1. Introduction

The global economy faces contradictory challenges: rising economic opportunities (due to several factors, such as digital technologies and innovation) together with increasing environmental pressure and crises (i.e., Covid 19, war in Ukraine, energy crisis). Developing economies are more challenged due to their low capacity to address opportunities and avoid risks and threats. Also, their efforts to survive in this turbulent time are coupled with the concern of catching up with the level of developed countries in terms of living standards for their citizens.

Green growth, as defined by the OECD (2011), can be seen as an option to keep the path of economic development without harming the quality of the environment. Green growth is about promoting economic growth based on the preservation of natural assets needed to provide environmental resources and services on which our well-being is based. It means that boosting investment and innovation will support sustained growth and new economic opportunities (OECD, 2011).

The paper analyses the determinants of green growth in the Central and Eastern European Union (EU) countries, by using economic complexity instead of economic growth, given the fact that it is identified as a predictor of economic growth (i.e., Hausman and Hidalgo, 2011; Neagu, 2019; Neagu and Neagu, 2022) along with other factors revealed by the current literature: human capital, globalization, renewable energy consumption and quality of institutions. Based on a panel approach with data covering the period of 1996-2020 for eleven developing EU countries, two regression models (FMOLS and DOLS) are estimated. We found that economic complexity, globalization, human capital and renewable energy are positively correlated with green growth. Institutional quality had also, a positive validated influence on green growth, but only for one estimated model (FMOLS).

The added value of the paper mainly consists of introducing the economic complexity variable among the determinants of green growth, by enriching in this way the literature regarding the impact of economic complexity on the economy and environment. Further, the findings of the paper are valuable for guiding policies in the CEE countries to ensure their integration in the European and global commitments (European Green Deal, EU-as climate-neutral by 2050, the 2030 Agenda on Sustainable Development, Sustainable Development Goals), and, specifically, on providing support for policies that promote green growth in the CEE countries.

The remainder of the paper is organized as follows. After the Introduction, the Literature Review section discusses the main studies on the paper's topic. It is followed by the Data and Methodology section where data and methods used in the study are explained. The section of Main Results describes the findings of the study and the last section is dedicated to Conclusions and Policy Implications.

2. Literature Review

Limited literature addresses the issue of determinants of green development, most of the economic and energy factors being studied in their relation to sustainable development. The study of Tawiah et al. (2021) examines economic, energy and institutional factors that influence green growth in 123 developed and developing countries. They found that economic development positively influences green growth, trade openness is detrimental, renewable energy improves green growth and institutional quality has no relevance.

In the lines below, the main determinants of green growth are discussed, as they are suggested by previous studies.

2.1. Economic complexity, economic growth and environment

In recent research economic development is understood as a process of learning for countries to produce and export sophisticated products. Therefore, each country has to identify its path of development and its unique means of learning system meant to develop its capabilities to compete in the global context (Lall, 1992; Lall, 2000). Such capabilities include, among others, intangible inputs (e.g., tacit knowledge), which are important in the production of sophisticated goods. Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) introduced a methodology for expressing the complexity (sophistication) of productive structure, generating the economic complexity index. Economic complexity refers to 'the composition of a country's productive output, reflecting its structures that hold and combine knowledge' (Hausman et al., 2014).

The economic complexity level of a country is based on its income level. Economic complexity is an accurate predictor of economic growth (i.e., Bustos et al., 2012; Felipe et al.,2012; Poncet and de Waldemar, 2013; Cristelli et al., 2015; Őzgüzer and Binatli, 2016; Ferrarini and Scaramozzino, 2013; Hausmann and Hidalgo, 2011; Chavez et al., 2017; Tachella et al., 2018). Developing countries must attract resources and develop the capabilities they need in order to increase the economic complexity level. Economic complexity affects the economy, society, and environment. It contributes to air pollution (i.e., Neagu and Teodoru, 2019; Abbasi et al., 2021) and the extension of ecological footprint (Lapatinas et al., 2019; Neagu, 2020; Boleti et al. 2021; Shahzad et al., 2021; Rafique et al., 2021; Ikram et al., 2021). A reduced number of studies report a decreasing effect of economic complexity on pollution (i.e., Dogan et al., 2021; Romero and Gramkov, 2021).

Studies focused on Environmental Kuznets Curve (EKC) models including the economic complexity index as an explanatory variable of environmental degradation show that a certain level of economic complexity can alleviate pollution (i.e., Can and Gozgor, 2017; Neagu, 2019; Pata, 2021). This conclusion is validated in the most complex economies, according to Neagu (2019) (i.e., France, Finland, Belgium, Italy).

2.2. Globalisation, economic growth and environment

Ofori and Figari (2023) found that economic globalization has a hampering effect on inclusive economic growth in 23 African countries. Liu et al. (2022) focused on eight South-Asian countries from 1996 to 2019 and found that globalization influences economic growth. The literature exploring the effect of globalization on the environment shows controversial results: a part reveals a positive correlation and another part, a negative one. In the group of studies revealing a negative correlation we can name: Shahbaz et al. (2017) for China; Patel and Mehta (2023) for India; Islam et al. (2021) for Bangladesh; Lv and Xu (2018) for 15 emerging countries; You and Lv (2018) for 83 countries; Rahman et al., (2019) for MENA countries; Koengkan et al. (2020) for 18 Latin American and Caribbean economies; Aladejare (2022) for the five richest African economies; Ansari et al. (2022) for ten carbon emitters developing countries. In the other group of studies revealing a positive correlation between globalization and the environment, we can include Shahbaz et al. (2018a) for Japan; Shahbaz et al. (2018) b for 25 developed countries; Wang et al., (2019) for OECD countries; Sethi et al., (2020) for India; Ling et al. (2020) and Wu et al. (2022) for China; Anser et al. (2021) for South-Asian economies; Murshed et al.., (2022) for Argentina; Tian and Li (2022) for G20 countries.

2.3 Human capital and environmental quality

Human capital is included in the analyses regarding the impact of economic development on environmental quality. Some studies on developing countries reveal that education is a significant determinant of environmental performance (i.e., Hettige et al.,1996), and also, for alleviating the pollution induced by foreign direct investment (i.e., Lan et al., 2011). Zhu (2022) investigates the role of human capital in sustainable development in the case of the Chinese economy, concluding that human capital is positively associated with Sustainable Development Goals (SDG). The study of Zafar et al. (2019) explores the impact of human capital alongside other variables (natural resources, foreign direct investment) on the ecologically friendly development of the economy of the USA. It is documented that healthy, well-educated, and skilled workers (high-quality human capital in other words) can improve the environmental performance of the economy. Similar results were reported by de Guimaraes et al. (2020) in the case of a survey conducted on 829 citizens from Brazil. It is highlighted that when human resources are aware of the environmental needs, knowledge and skills can enable ecologically friendly policies, which results in carbon emission reduction. Ahmad et al (2022) found that human capital reduced the ecological footprint in emerging countries. Kim and Go (2020) emphasized, by using a sample of 72 countries, the positive role of human capital in enhancing awareness and compliance with environmental regulations, leading in this way to the increase of environmental performance.

2.4. Renewable energy and environment

An impressive literature shows that renewable energy use reduces pollutant emissions in all countries (some examples: Alola and Joshua, 2020; Jebli et al. 2020; Khan et al., 2020; Saidi and Omri, 2020). The same results were reported by: Koengkan et al. (2020) for Latin American and Caribbean nations; Adebayo et al. (2021) for Brazilia; Murshed et al. (2022) for Argentina; Wu et al. (2022) for Nordic countries; Ansari et al. (2022) for developing countries; Kwakwa (2023) for African countries, and Cao et al. (2023) for OECD countries.

2.5. Institutional quality and environment

According to Kuncic (2014) term institutional quality refers to the quality of the governance system of a country, consisting of a set of norms and regulations meant to operate in the economic, social, and political framework. As the institutions shape the public policies in economic, energy and environmental areas, it is important to consider institutional variables in analyses regarding these issues.

Several studies are focused on the role of institutional quality in mitigating pollution (i.e., Kim et al., 2020; Ahmad et al., 2022; Simionescu et al., 2022 a, b). Sheraz et al. (2022) pointed out that low institutional quality is correlated with environmental degradation and corruption and increased carbon emissions in Asian countries, according to Rahman and Alam (2022). Institutional quality can reduce carbon emissions (Jahanger et al., 2023; Karim et al., 2022; Khan et al., 2022; Acheampong et al., 2021; Khan and Rana, 2021).

3. Data and Methodology

3.1. Data

The study is focused on 11 Central and Eastern European countries (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovak Republic, and Slovenia). As developing economies, these countries are struggling with catching-up strategies to converge to the mean income average of the European Union and develop their capacity to be resilient to inherent shocks of the current international context (energy crisis, war in Ukraine, consequences of Pandemic). Data used in the study cover 26 years (1996-2020).

The dependent variable is the green growth indicator, as it is defined by OECD (2022; 2011). It measures the efficient use of natural capital and indicates whether economic growth has become greener, by capturing aspects of production that are not quantified in other economic or accounting models. More specifically, the green growth indicator expresses a country's environmental and resource productivity, comprising carbon and energy productivity, resources productivity (materials, nutrients, water) and multifactor productivity. Higher values of this indicator suggest a „greener" economic growth (OECD, 2011).

Based on previous studies on determinants of green growth (i.e., Tawiah et al., 2021) we include the following explanatory variables of green growth in the CEE countries: economic complexity (as a proxy for economic growth), globalization, human capital, institutional quality, and renewable energy consumption.

Economic complexity refers to the level of sophistication of the productive structure of the economy, reflecting its capacity to hold combined and knowledge (Hausman et al., 2014). Several studies provide evidence in support of the stable and positive correlation of economic complexity with economic growth (i.e., Hidalgo, 2021; Özgüzer and Binalti 2016; Cristelli et al., 2015; Poncet de Waldemar, 2013; Felipe et al., 2012; Bustos et al., 2012). Moreover, it is considered a good predictor of economic growth (Tachella et al., 2018; Chavez et al., 2017; Hausmann and Hidalgo, 2011; Hidalgo and Hausmann, 2009). Given these findings, we will use in our analysis the economic complexity index as a proxy for economic growth. The economic complexity index (ECI) was introduced by Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) as an approximation of the level of complexity of a country's productive structure, taking into consideration two dimensions of complexity: diversity (number of produced goods with revealed comparative advantage) and ubiquity (number of countries able to export goods with revealed comparative advantage.

Human capital is a key driver of economic growth. It refers to the knowledge embedded in individuals, skills, education and experience at work. In a conceptual view, the human capital of a nation includes formal education, health status of individuals and some forms of social capital (Neagu, 2010, pp.13-22). An impressive number of studies highlights the role of human capital in economic development (some examples: Mincer, 1984, Becker, 1997; de la Fuente and Domenech, 2006; Tamura, 2004; Hanushek, 2013; Pelinescu, 2015; Tahir et al., 2020; Geng, 2022; Wirajing et al., 2023). The Penn World Table, developed by Feenstra (University of California) and Inklaar and Timmer (University of Groningen) introduced a human capital index which is computed considering the average years of schooling from Barro and Lee (2013) and rate of return to education (Psacharopoulos, 1994) (Feenstra et al., 2015).

Introduced by Dreher (2003) (the KOF Swiss Institute), the KOF index of globalization captures three dimensions of this phenomenon: economic, social, and political. It is also computed as an overall KOF index of globalization, including all dimensions. The index has been updated several times (i.e., by Dreher et al., 2008 and by Gygli et al., 2018, 2019). An impressive volume of studies reveals the positive effects of globalization on economic growth (i.e., the meta-analysis developed by Heimberger, 2021) and also on the environment (i.e., Sethi et al., 2020; Anser et al., 2021; Huo et al., 2022; Ivanovski and Hailemariam, 2022; Jahanger et al., 2022).

Renewable energy consumption is found in several studies as a reducing factor of pollutant emissions (i.e., Raihan, 2023), and also a contributor to economic growth (Neagu et al., 2021). It is generally expressed as the share of energy use sourced from renewables (wind, solar, biomass) in the total final energy consumption.

Our analysis includes also a variable reflecting the institutional quality in the economies included in the study. The reason for including such a variable consists of the fact that institutional quality is revealed in several studies as a moderating factor of pollution mitigation (i.e., Jahanger et al., 2023, Simionescu et al.,2022; Jiang et al., 2022; Khan et al., 2022; Acheampong et al., 2021; Khan and Rana, 2021). Also, it is revealed to promote economic development in developing nations (i.e., Uddin et al., 2023; Yildirim and Gökalp, 2016). We used the governance indicators sourced from the Worldwide Governance Indicators database (WGI) and introduced by Kaufman and Kray (2018) as a proxy for institutional quality, used in several studies (i.e., Jahanger et al., 2023; Neagu et al. 2023; Simionescu et al., 2022a, 2002b; Tawiah et al., 2021). We computed an index of institutional quality by using the Principal Component Analysis (PCA) based on the six governance indicators (rule of law, voice and accountability, control of corruption, government effectiveness, absence of violence, and regulatory quality), following prior studies such as Uddin et al. (2023); Tawiah, et al. (2021); Konara and Shirodkar (2018). The PCA technique shows how the variation of a variable is explained by a given component. The primary component is computed based on the eigenvalues (the six governance indicators, in our case) of the sample covariance matrix. As a result, the number of principal components is equal to the number of variables, meaning that the first principal component can explain most of the variation, and its value is used to compute the index. The values of the constructed index for the economies included in the study for the period of 1996 to 2020 are displayed in the Appendix. We found that our constructed index is correlated with the average of the six governance indicators.

Table 1 displays the variables under consideration and their sources.

Table 1 Variables and their sources

Acronym	Name	Explanation	Source
Dependent variable			
GD	Green Development	Environmental and resource productivity (US dollars per kg, 2015)	OECD, Green Growth Indicator

Explanatory (independent) variables			
ECI	Economic Complexity Index	The complexity of products that a country exports.	Harvard's Growth Lab
KOF	Globalisation Index	Overall Globalisation Index	KOF Swiss Economic Institute
HCI	Human Capital Index		Penn World
RE	Renewable Energy	Renewable Energy consumption: the share of energy consumption from renewable sources in the total final energy consumption	World bank
IQ	Institutional Quality	Institutional quality Index computed as the result of applying PCA methods for the following indicators: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, Voice and Accountability	World Governance Indicators (WGI)

Source: Own processing.

Table 2 provides the descriptive summary statistics of the variables under consideration. All variables are in ln. We can note that the standard deviation is generally low, the highest is recorded for lnIQ (1.0657), and the lowest for lnHCI (0.1058), respectively.

Table 2 Statistic description of variables

	Mean	Median	Maximum	Minimum	Standard Deviation
lnGD	1.5281	1.5810	2.7638	0.0487	0.4323
lnECI	-0.1850	0.0442	0.7007	-6.329	0.7440
lnKOF	4.3740	4.3973	4.5098	3.9482	0.1078
lnHCI	1.1389	1.1470	1.3478	0.7453	0.1058
lnRE	2.5687	2.6925	4.0673	0.1397	0.8136
lnIQ	0.8383	1.1825	2.5552	-3.9406	1.0657

Source: computation based on using E-Views 12.0 software

3.2 Model and Econometric Strategy

Following the considerations of Tawiah et al. (2021) the model used in our study is the following:

$$lnGD_{i,t} = \alpha + \beta_1 \cdot lnECI_{i,t} + \beta_2 \cdot lnKOF_{i,t} + \beta_3 \cdot lnHCI_{i,t} + \beta_4 \cdot lnRE_{i,t} + + \beta_5 \cdot lnIQ_{i,t} + \varepsilon_{i,t} \quad (1)$$

where: i denotes the cross-section (country) and t the time, respectively; GD represents the OECD green development index; ECI is the economic complexity index, KOF refers to the KOF globalization index (overall), HCI means the human capital index, RE stands for renewable energy consumption (% from the total final consumption), IQ express the institutional quality index (computed by authors), $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are the coefficients to be estimated, and $\varepsilon_{i,t}$ is the stochastic error term.

Our empirical analysis is based on a panel data approach, following the steps below: (i) cross-sectional dependence tests (Breusch-Pagan (1980), Pesaran Scaled LM, Bias-corrected scaled LM and Pesaran CD tests Pesaran, (2004); (ii) checking the stationarity of the considered variables by using second-generation unit root tests proposed by Pesaran (2007)(Cross-Sectional Augmented Dickey-Fuller (PES-CADF) and Cross-Sectional IM, Pesaran and Shin (CHIPS)) ; (iii) testing the cointegrating relationship among variables with the Kao residual cointegration test; (iv) estimation of the long-run coefficients by using the FMOLS and DOLS techniques; (v) testing the causality relationship between variables.

4. Main Findings and Discussion

In Table 3 we notice that the values of Prob (indicated by *) are under 0.01 for all considered variables. This suggests rejecting the null hypothesis of no cross-sectional dependence and accepting the alternative, meaning the presence of cross-section dependence among our variables.

Table 3 Results of the cross-sectional dependence test

	Breusch-Pagan LM	Pesaran Scaled LM	Bias-corrected Scaled LM	Pesaran CD
lnGD	1220.688*	111.144*	110.144*	34.890*
lnECI	894.652*	80.057*	79.828*	29.473*
lnKOF	986.832*	88.846*	88.607*	31.227*
lnHCI	1285.127*	117.288*	117.058*	35.815*
lnRE	864.758*	77.207*	76.978*	28.696*
lnIQ	383.397*	31.311*	31.082*	4.335*

Source: Authors' own computation based on EViews 12.0 software

Note: *$p < 0.01$

Table 4 depicts the result of applying the unit root tests for our variables. Excepting the HCI variable, all other variables are stationary at their level, for both tests and both options (constant/constant and trend), the value of Prob. being lower than 1%, 5% and 10%. The value of Prob. for the first difference series in the case of HCI (ΔlnHCI) is under 0.01, which indicates the presence of stationarity.

Table 4 Stationarity test

Variable	**CIPS test CIPS statistic**		**PES-CADF Z(t-bar)**	
	constant	*constant and trend*	*constant*	*constant and trend*
lnGD	-2.305	-2.375	-1.369***	0.193
ΔlnGD	-4.460*	-4.600*	-7.326*	-6.209*
lnECI	-2.597*	-2.810**	-3.596*	-2.136**
ΔlnECI	-5.233*	-5.443*	-7.534*	-7.134*
lnKOF	-1.853**	-2.836**	-1.422**	-1.698**
ΔlnKOF	-6.860*	-6.458*	-5.888*	-4.418*
lnHCI	-1.941	-2.459	-3.604*	-2.112**
ΔlnHCI	-1.990*	-2.756*	-4.925*	-5.094*
lnRE	-2.514*	2.452	-2.921*	0.167
ΔlnRE	-4.737*	-4.960*	-5.520*	-3.976*
lnIQ	-2.939*	-3.704*	-1.031	-1.756**
ΔlnIQ	-5.177*	-5.506*	-7.748*	-7.465*

Note: *p < 0.01; ** p < 0.05; ***p<0.1
Source: authors' computation based on Stata 15 software

Given the fact that our variables are integrated by their first order I (1) (not all stationary at their level) we use the KAO residual cointegration test for testing the long-run relationship among variables (Table 5).

Table 5 Cointegration test result (Kao test)

Kao Residual Cointegration Test
Series: LNGD, LNECI, LNKOF, LNHCI LNIQ LNRE
Null Hypothesis: No cointegration

	rho	Prob.	t-Statistic	Prob.
DF	-7.199933	0.0000	-4.421609	0.0000
DF*	-4.331964	0.0000	-3.532550	0.0002

Source: Authors' own computation based on EViews 12.0 software

According to the results displayed in Table 5, the null hypothesis of no cointegration among the considered variables is rejected due to the values of Prob. under 0.01. It indicates the variables are cointegrated in the long run, meaning that they have a stable, long-run equilibrium relationship.

Table 6 displays the result of the estimation of regression equation 1, for FMOLS and DOLS models.

Table 6 Estimation results

	FMOLS	DOLS
Variables	**coefficients**	
lnECI	0.028*	0.040*
lnKOF	0.832*	0.768*
lnHCI	3.087*	3.322*
lnRE	0.166*	0.137*
lnIQ	0.016*	0.012***
R-squared	0.9487	0.9467

Source: authors' own computation based on EViews 12.0 Software
Note: *p<0.01; ***p< 0.1

As we can notice from Table 6, all coefficients are positive, indicating a positive correlation of explanatory variables with the independent variable (green development).

In the FMOLS model, all coefficients are statistically validated for a 1% significance. Human capital has the highest influence on green development: when HCI increases by one percentage point, green development will increase by 3.087 percentage points. An increase of 1% in the KOG globalization index will lead to an increase of 0.832% in green development. The 1% increase in economic complexity will induce a 0.02% increase in green development. Renewable energy consumption and institutional quality are also positively correlated with green development variables. In the DOLS model, used for checking the robustness of results, the coefficients of all variables are statistically significant.

We revealed that economic complexity is a significant determinant of green development in both models. This suggests that high economic complexity could promote sustainable environmental growth, despite a preliminary perception that economic complexity could be seen as a new challenge for the environment (Neagu, 2021) because it is also proved that high-income countries with high complexity of the products they export are able to alleviate pollution and environmental depreciation (the Environmental Kuznets Curve model being validated) (i.e., Neagu and Neagu, 2022).

Our result showing that economic complexity is significant for green growth is consistent with previous studies on green complexity developed by Mealy and Teytelboym (2022).

Our result regarding the positive correlation between globalization and green development is contradictory with the findings of Tawiah et al. (2021) who identified a negative correlation between green growth and internationalization (i.e., foreign direct investment and trade openness) in developed and developing countries.

Renewable energy consumption was also found a contributor to green development by Tawiah et al. (2021) suggesting that renewable energy sources could make effective use of natural assets in the general production and consumption process.

Institutional quality is found to be significant for green growth in both models. This result contradicts the conclusions of Tawiah et al. (2021) in their study of developing and developed countries.

Table 7 Dumitrescu-Hurlin causality test

Null hypothesis	**W-stat.**	**z-bar stat.**	**Prob.**
lnGD does not Granger -cause lnECI	4.13200	5.92107	0.0000
lnHCI does not Granger- cause lnGD	7.50386	12.5173	0.0000
lnIQ does not Granger -cause lnGD	2.14050	2.02520	0.0428
lnGC does not Granger-cause lnIQ	4.31734	6.28363	0.0000
lnKOF does not Granger -cause lnGD	2.61733	2.95799	0.0033
lnGD does not Granger cause lnRE	4.60408	6.84457	0.0000

Source: authors' computation based on EViews 12.0 software
Note: Lag=1

As a result of applying the causality test (Table 7), the following unidirectional causal relations were identified as validated: running from ECI, HCI and RE to GD and from GD to KOF. This confirms our preliminary assumptions that economic complexity, human capital and renewable energy use are influencing green growth, being significant to its determinants. The correlation between KOF and green development can be understood in the sense that progress on green development may stimulate business internationalization and connections between countries and people. It also revealed a bidirectional causality relationship between IQ and GD, suggesting that institutional quality is important for green growth, and conversely, achievements on the path of green growth can boost institutional quality in the CEE countries.

5. Conclusions and Policy Implications

Our paper investigates the determinants of green development in eleven Central and Eastern European Union countries, with a focus on a new potential green driver, economic complexity, which is the novelty of the study. Using a panel approach and FMOLS and DOLS techniques for regression estimation, we revealed that economic complexity is a significant determinant of green development in these countries in the period under examination (1996-2020). Human capital is found as a consistent contributor to green development. Globalization is also identified as a determinant of green development, as well as renewable energy consumption. We also found that institutional quality is not significant for green development in one of the used models.

The causality test revealed the following types of causal relationships: (i) unidirectional ones from ECI, HCI and RE to green growth, and from green growth to KOF, and (ii) bidirectional, between IQ and green growth.

Our findings are overall relevant for the European Union targets assumed through the European Green Deal and climate neutrality by 2050. More specifically, as policy implications of our results, we can suggest the following public policy measures: (i) a higher economic complexity can be achieved through high quality inputs, meaning productive capabilities based on a green industrial development (green products) and accumulation of green capabilities (green technologies), in other words, to design and implement a green industrial policy at the EU level; (ii) support for further human capital investment in all countries, a high quality of human capital would enable green growth, being beneficial as input for economic complexity, and also as citizens behaviour enabling protection of natural assets; (iii) even globalisation is correlated with green growth, international business policy must be carefully oriented to avoid transfer of polluting intensive operations in Eastern countries, which would have a negative effect on green growth; moreover, promotion of sustainable business models through an appropriate legislative framework, as suggested by Kajanova et al. (2022) could support green growth; (iv) renewable energy use must be further promoted through tax policies, subsidies and loans on a permanent basis, under the EU policy on renewable energy; (v) governments should continue to take into consideration the strengthening of public institutions, as suggest De Angelis et al. (2019) and Wolde-Rufael and Weldmeskel (2020) regarding the environmental policy stringency and to gain effectiveness in achieving green growth. Moreover, the concept of green public procurement should be largely promoted and used (Malatinec 2017, 2021) as an example of environmentally responsible behavior.

As further directions of research, further and deeper analysis taking into consideration various channels of green growth (i.e., investment in green and clean technologies, research and development, financial development, and other governance indicators) could be developed.

Acknowledgments
The authors thank the anonymous reviewers and editors for their valuable contributions.

Funding
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector.

Author Contributions
The authors contributed equally to this work.

Disclosure statement
The authors have not any competing financial, professional, or personal interests from other parties.

References
1. Ag Abbasi, K.R., Lv, K., Radulescu, M., Shaikh, P.A. (2021), Economic complexity, tourism, energy prices, and environmental degradation in the top economic complexity panel: Fresh panel evidence, Environmental Science and Pollution Research, 28948), 68717-68731. (https://doi.org/10.1007/s11356-021-15312-4).
2. Acheampong, A.O., Dzator, J., Savage, D.A. (2021), Renewable energy, CO2 emissions and economic growth in sub-Saharan Africa: Does institutional quality matter? Journal of Policy Modelling 43, 1070-1092. (https://doi.org/10.1016/j.polmod/2021.03.011).
3. Adebayo, T.S., Adedoyin, F.F., Kirikkaleli, D. (2021), Toward a sustainable environment: nexus between consumption-based carbon emissions, economic growth, renewable energy and technological innovation in Brazil, Environmental Science and Pollution Research, 28,52272-52282. (https://doi.org/10.1007/s11356-021-14425-0).
4. Ahmad, M., Ahmed, Z., Yang, X.Y., Hussain, N., Sinha, A. (2022), Financial development and environmental degradation: do human capital and institutional quality make a difference? Gondwana Research, 105, 99–310. (https://doi.org/10.1016/J.GR.2021.09.012).
5. Aladejare, S.A. (2022), Natural resource rents, globalization and environmental degradation: New insight from 5 richest African economies, Resources Policy, 78, 102909. (https://doi.org/10.1016/j.resourpol.2022.102909)
6. Alola, A.A., Joshua, U. (2020), Carbon emission effect of energy transition and globalization: inference from the low-, lower-middle-, upper-middle-, and high-income countries, Environmental Science and Pollution Research, 27:38276-38286. (https://doi.org/10.1007/s11356-020-09857-z).
7. Ansari, M.A., Akram, V., Haider, S. (2022), A link between productivity, globalization and carbon emissions: evidence from emissions by coal, oil and gas, Environmental Science and Pollution Research, 29:33826-33843. (https://doi.org/10.1007/s11356-022-18557-9).

8. Ansari, M.A., Akram, V., Haider, S. (2022), A link between productivity, globalization and carbon emissions: evidence from emissions by coal, oil and gas, Environmental Science and Pollution Research, 29, 33826-33843. (https://doi.org/10.1007/s11356-022-18557-9).
9. Anser, M.K., Usman, M., Godil, D.I., Shabbir, M.S., Sharif, A., Tabash, M.I., Lopez, L.B. (2021), Does globalisation affect green economy and environment? The relationship between energy consumption, carbon dioxide emissions, and economic growth, Environmental Science and Pollution Research, 28, 51105-51118. (https://doi.org/10.1007/s11356-021-14243-4)
10. Barro, R., Lee, J.-W. (2013), A new data set of educational attainment in the world, 1950-2010, Journal of Development Economics, 104, 184-198. (https://doi.org/10.1016/j.jdeveco.2012.10.001)
11. Becker, S. G. (1997), Capitalul uman. O analiză teoretică și empirică cu referire la educație, Editura All, București.
12. Boleti, E., Garas, A., Kyriakou, A., Lapatinas, A. (2021), Economic complexity and environmental performance: Evidence from a world sample, Environmental Modeling & Assessment, 26, 251-270. (https://doi.org/10.1007/s10666-021-09750-0).
13. Bustos, S., Gomez, C., Hausmann, R.: Hidalgo, C.A. (2012), The dynamics of nestedness predicts the evolution of industrial ecosystem, PloS One, 7(11). e49393. (https://doi:10.1371/journal.pone.004939).
14. Can, M., Gozgor, G. (2017), The impact of economic complexity on carbon emissions: Evidence from France, Environmental Science and Pollution Research 24, 16364–16370. (https://doi.org/10.1007/s11356-017-9219-7).
15. Cao, H., Khan, M.K., Rehman, A., Dagar, V., Oryani, B., Tanveer, A. (2022), Impact of globalization, institutional quality, economic growth, electricity and renewable energy consumption on carbon dioxide emission in OECD countries, Environmental Science and Pollution Research, 29, 24191-24202. (https://doi.org/10.1007/s11356-021-17076-3).
16. Chavez, J.C., Mosqueda, M.T., Gomez-Zaldivar, M. (2017), Economic complexity and regional growth performance: evidence from the Mexican economy, Review of Regional Studies 47, 201-219.
17. http://journal.srsa.org/ojs/index.php/RRS/article/download/876/pdf (accessed on 22 August 2023).
18. Cristelli, M., Tacchella, A., Pietronero, L. (2015), The heterogeneous dynamics of economic complexity, PloS One, 10(2), e0117174. (https://doi: 10.1371/journal.pone.0117174 PMID: 25671312).
19. De Angelis, E.M., Di Giacomo, M., Vannoni, D. (2019), Climate change and economic growth: the role of environmental policy stringency. Sustainability 11, 2273. (https://doi.org/10.3390/su11082273).
20. De Guimaraes, J. C. F., Severo, E. A., Junior, L. A. F., Da Costa, W. P. L. B., Salmoria, F. T. (2020), Governance and quality of life in smart cities: Towards sustainable development goals, Journal of Cleaner Production, 253,119–142. (https://doi.org/10.1016/j.jclepro.2019.119926).

21. Dogan, B., Driha, O.M., Balsalobre Lorente, D., Shahzad, U. (2021), The mitigating effects of economic complexity and renewable energy on carbon emissions in developed countries, Sustainable Development, 29, 1–12. (https://doi.org/10.1002/sd.2125).
22. Dreher, A. (2003), Does Globalization Affect Growth? University of Mannheim, Working Paper. Available at: https://ssrn.com/ abstract=348860
23. Dreher, A., Gaston, N., Martens, P. (2008), Measuring Globalisation: Gauging its Consequences. New York: Springer Science Business Media, LLC. Available at: https://welfens.wiwi.uni-wuppertal.de/fileadmin/welfens/daten/Materialien/Measuring_Globalisation__Gauging_Its_Consequences.pdf
24. Felipe, J., Kumar, U., Abdon, A., Bacate, M. (2012), Product Complexity and Economic Development, Structural Change and Economic Dynamics 23, 36–68. (https://doi:10.1016/j.strueco.2011.08.003).
25. Feenstra, R., Inklaar, R., Timmer, M. (2015), The next generation of the Penn World Table, The American Economic Association, The American Economic Review 105 (10), 3150-3182. (www.ggdc.net/pwt).
26. Ferrarini, B., Scaramozzino, P. (2013), Complexity, specialisation and growth. Working Paper No.344, Asian Development Bank. Available online: http://hdl.handle.net/11540/2329 (accessed on 5 September 2023).
27. de la Fuente, A. and Domenech, R. (2006), Human capital in growth regressions: how much difference does data quality make? Journal of Europe Economic Association, Vol.4, No.1, 1-36. (https://doi.org/10.1162/jeea.2006.4.1.1.)
28. Geng, H. (2022), The relationship between human capital and economic growth beyond logarithmic production function, Advances in Multimedia, 6554127. (https://doi.org/10.1155/2022/6554127).
29. Gygli, S., Haelg, F., Poftrake, N., Sturm, J.E. (2018), The KOF Globalization Index–Revisited, CESifo Working Paper, No. 7430, Center for Economic Studies and IFO Institute, Munich, Available at: http://hdl.handle.net/10419/198790
30. Gygli, S., Haelg, F., Potrafke, N., Sturm, J.E. (2019), The KOF Globalisation Index-revisited, The Review of International Organizations, 14, 543-574. (https://doi.org/10.1007/s11558-019-09344-2).
31. Hanushek, E.A. (2013), Economic growth in developing countries: the role of human capital, Economics of Education Review, 37, 204-212. (https://dx/doi.org/10.1016/j.econedurev.2013.04.005).
32. Harvard's Growth Lab (2023), Country Complexity Rankings, Harvard Kennedy School. (https://atlas.cid.harvard.edu/rankings).
33. Hausmann, R., Hidalgo, C.A. (2011), The network structure of economic output, Journal of Economic Growth 16, 309–342. (https://doi.org/10.1007/s10887-011-9071-4).
34. Hausmann, R., Hidalgo, C.A., Bustos, S., Coscia, M., Simoes, A., Yildirim, M.A. (2014), The Atlas of Economic Complexity: Mapping Paths to Prosperity; MIT Press: Cambridge, MA, USA, Available online: https://s3.amazonaws.com/academia.edu.documents/30678659/ (Accessed on 6 September 2023).

35. Heimberger, Ph. (2021), Does economic globalisation promote economic growth? A meta-analysis, The World Economy, 45, 1690-1712. (https://doi.org/10.1111/twec.13235).
36. Hettige, H., Huq, M., Pargal, S., Wheeler, D. (1996), Determinants of pollution abatement in developing countries: Evidence from South and Southeast Asia, World Development, 24, 1891–1904. (https://doi.org/10.1016/S0305-750X(96)00076-9).
37. Hidalgo, C.A., Klinger, B., Barabasi, A.L., Hausmann, R. (2007), The product space conditions the development of nations, Science, 317, 482–487. (http://doi.10.1126/science.1144581).
38. Hidalgo, C.A., Hausmann, R. (2009), The building blocks of economic complexity, Proceedings of National Academy of Sciences USA, 106, 10570–10575. (https://doi.org/10.1073/pnas.0900943106).
39. Hidalgo, C.A. (2021), Economic complexity theory and applications, Nature Review. Physics, 3, 92–113. (https://doi.org/10.1038/s42254-020-00275-1).
40. Hidalgo, C.A., Hausmann, R. (2009), The building blocks of economic complexity. Proceedings of the National Academy of Sciences, 106, 10570–10575. (https://doi.org/10.1073/pnas.0900943106).
41. Hidalgo, C.A. (2021), Economic complexity theory and applications, Nature Reviews. Physics, 3, 92–113. (https://doi.org/10.1038/s42254-020-00275-1).
42. Huo, Ch., Hameed, J., Sharif, A., Albasher, G., Alamri, O., Alsultan, N., ul-ain Baig, N. (2022), Recent scenario and nexus of globalization to CO2 emissions: Evidence from wavelet and Quantile on Quantile Regression approach, Environmental Research, Vol.212 Part A, Sept. 2022, 113067. (https://doi.org/10.1016/j.envres.2022.113067).
43. Islam, M., Khan, M.K., Tareque, M., Jehan, N., Dagar, V. (2021), Impact of globalization, foreign direct investment, and energy consumption on CO2 emissions in Bangladesh: Does institutional quality matter? Environmental Science and Pollution Research, 28:48851-48871. (https://doi.org/10.1007/s11356-021-13441-4).
44. Ikram, M., Xia, W., Fareed, Z., Shahzad, U., Rafique, M.Z. (2021), Exploring the nexus between economic complexity, economic growth and ecological footprint, Contextual evidences from Japan, Sustainable Energy Technologies and Assessments, 47, 191460. (https://doi.org/10.1016/j.seta.2021.101460).
45. Ivanovski, K., Hailemariam, A. (2022), Is globalization linked to CO2 emission? Evidence from OECD nations, Environmental and Ecological Statistics, 29, 241-270. (https://doi.org/10.1007/s10651-021-00520-5).
46. Jahanger, A., Yang, B: Huang, W.-C., Murshed, M., Usman, M., Rădulescu, M. (2022), Dynamic linkages between globalisation, human capital and carbon dioxide emissions: empirical evidence from developing countries, Environment, Development and Sustainability, 25, 9307-9335. (https://doi.org.10.1007/s10668-022-02437-w).
47. Jahanger, A., Usman, M., Ahmad, P. (2023), Investigating the effects of natural resources and institutional quality on CO2 emissions during globalisation mode in developing countries, International Journal of Environmental Science and Technology, 20, 9663-9682. (https://doi.org/10.1007/s13762-022-04638-2).

48. Jebli, M. B., Farhani, S., Guesmi, K. (2020), Renewable energy, CO2 emissions and value added: Empirical evidence from countries with different income levels, Structural Change and Economic Dynamics, 53(2). 402–410. (https://doi.org/10.1016/j.strueco.2019.12.009).
49. Jiang, Q., Rahman, Z.U., Zhang, X., Guo, Z., Xie, Q. (2022), An assessment of the impact of natural resources, energy, institutional quality, and financial development on CO2 emissions: Evidence from B&R nations, Resources Policy, 76, 102716. (https://doi.org/10.1016/j.resourpol.2022.102716).
50. Kajanova, J., Matusova, S., Novacek, P. (2022), Sustainable business in the European economic area, Juridical Tribune, 12 (4). 495-508.
51. Karim, S., Appiah, M., Naeem, M.A., Lucey, B.M., Li, M. (2022), Modelling the role of institutional quality on carbon emissions in Sub-Saharan African countries, Renewable Energy, 198, 213-221, (https://doi.org/10.1016/j.renene.2022.08.074).
52. Kaufmann, D. and Kraay, A (2018), The worldwide governance indicators. The World Bank. (https://info.worldbank.org/governance/wgi/)
53. Khan, M. K., Khan, M. I., Rehan, M. (2020), The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan, Financial Innovation, 6(1), 1–13. (https://doi.org/10.1186/s40854-019-0162-0).
54. Khan, A.A., Khan, S.U., Ali, M.A.S., Safi, A., Gao, Y., Ali, M., Luo, J. (2022), Role of institutional quality and renewable energy in achieving carbon neutrality: case study of G-7 countries, Science of Total Environment, 814, 152797. (https://doi.org/10.1016/j.scitotenv.2021.152797).
55. Khan, M., Rana, A.T. (2021), Institutional quality and CO2 emission-output relations: The case of Asian countries, Journal of Environmental Management 279, 111569. (https://doi.org/10.1016/j.envman.2020.111569).
56. Kim, D.-H., Wu, Y-C., Lin, S.C. (2022), Carbon dioxide emissions, financial development and political institutions, Economic Change and Restructuring, 55, 837-874. (https://doi.org.10.1007/s10644-21-09331-x).
57. Kim, D. and Go, S. (2020), Human capital and environmental sustainability, Sustainability, 12 (11), 4736. (https://doi.org/10.3390/su12114736).
58. Koengkan, M., Fuinhas, J.A., Santiago, R. (2020), Asymmetric impacts of globalisation on CO2 emissions of countries in Latin America and the Carribean, Environment Systems and Decisions, 40, 135-147. (https://doi.org/10.1007/s10669-019-09752-0).
59. KOF Globalisation Index, (2023), Available at: https://kof.ethz.ch/en/forecasts-andindicators/indicators/kof-globalisation-index.html
60. Konara, P. and Shirodkar, V. (2018), Regulatory institutional distance and MNCs' subsidiary performance: climbing up vs. climbing down the institutional ladder, Journal of International Management, 24, 333–347. (https://doi.org/10.1016/j.intman.2018.04.004).
61. Kuncic, A., (2014), Institutional quality dataset, Journal of Institutional Economics 10 (1): 135–161. (https://doi.org/10.1017/S1744137413000192).
62. Kwakwa, P.A. (2023), Climate change mitigation role of renewable energy consumption: Does institutional quality matter in the case of reducing Africa's carbon dioxide emissions? Journal of Environmental Management, 342, 118234. (https://doi.org/10.1016/j.jenvman.2023.118234).

63. Lall, S. (1992), Technological capabilities and industrialization, World Development, 20, 165–186. (https://doi.org/10.1016/0305-750x(92)90097-f).
64. Lall, S. (2000), The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-98, Oxford Development Studies, 28, 337–369. (https://doi.org/10.1080/713688318).
65. Lan, J., Kakinaka, M., Huang, X. (2011), Foreign direct investment, human capital and environmental pollution in China, Environmental and Resource Economics, 51, 255–275. (https://doi.org/10.1007/s106460-011-9498-2).
66. Lapatinas, A., Garas, A., Boleti, E., Kyriakou, A. (2019), Economic complexity and environmental performance: Evidence from a world sample, MPRA Paper, No. 92833. Available online: https://mpra.ub.uni-muenchen.de/92833/ (accessed on 5 August 2023).
67. Ling, G., Razzaq, A., Guo, Y., Fatima, T., Shahzad, F. (2022), Asymmetric and time - varying linkages between carbon emissions, globalization, natural resources and financial development in China, Environment, Development and Sustainability, 24, 6702-6730. (https://doi.org/10.1007/s10668-021-01724-2).
68. Liu, Y., Adejumo, A.V., Adejumo, O.O., Aderemi, T.A. (2022), Globalization and economic growth? A sustainability analysis for South-Asian countries, Global Policy, 13, 507-522. (https://doi.org/10.1111/1758-5899.13073).
69. Lv, Z., Xu, T. (2018), Is economic globalization good or bad for the environmental quality? New evidence from dynamic heterogeneous panel models, Technological Forecasting and Social Change, Vol.137, 340-343. (https://doi.org/10.1016/j.techfore.2018.08.004).
70. Malatinec, T. (2017), Legislative framework of green public procurement and Europeanisation of the Slovak practice, Juridical Tribune, 7, Special Issue, 95-107
71. Malatinec, T. (2021), Local barriers in the efficient use of Green Public Procurement - case of Slovakia, Juridical Tribune, 11 (3), 524-534
72. Mealy, P., Teytelboym, A. (2022), Economic complexity and the green economy, Research Policy, 51, 103948. (https://doi.org/10.1016/j.respol.2020.103948).
73. Mincer, J. (1984), Human capital and economic growth, Economics of Education Review, 3(3), 195-205. (https://doi.org/10.1016/0272-7757(84)90032-3).
74. Murshed, M., Rashid, S., Ulucak, R., Dagar, V., Rehman, A., Alvarado, R., Nathaniel, S.P. (2022), Mitigating energy production-based carbon dioxide emissions in Argentina: the role of renewable energy and globalization, Environmental Science and Pollution Research, 29, 16939-16958. (https://doi.org/10.1007/s11356-021-16867-y).
75. Neagu, O. (2010), Capitalul uman și dezvoltarea economică, Editura Risoprint, Cluj-Napoca.
76. Neagu, O. (2019), The link between economic complexity and carbon emissions in the European Union countries: a model based on Environmental Kuznets Curve approach, Sustainability, 11, 4753. (https://doi.org/10.3390/su11174753).
77. Neagu, O., Teodoru, M. (2019), The relationship between economic complexity, energy consumption structure and greenhouse gas emission: Heterogeneous panel evidence from the EU countries, Sustainability 11, 497. (https://doi.org/10.3390/ su11020497).

78. Neagu, O. (2020), Economic complexity and ecological footprint: Evidence from the most complex economies in the world, Sustainability, 12, 9031. (https://doi.org/10.3390/su12219031).
79. Neagu, O. (2021), Economic complexity: a new challenge for the environment, Earth, 2(4), 1059-1076. (https://doi.org/10.3390/earth2040063).
80. Neagu, O., Haiduc, C., Anghelina, A. (2021), Does renewable energy matter for economic growth in Central and Eastern European countries? Empirical evidence from heterogeneous panel cointegration analysis, Studia Universitatis "Vasile Goldiş" Economic Series, Vol. 31, Issue 1, 34-59. (https://doi.org/10.2478/sues-2021-0003).
81. Neagu, O., Neagu, M-I. (2022), The environmental Kuznets curve revisited: Economic complexity and ecological footprint in the most complex economies of the world, Studia Universitatis "Vasile Goldiş" Economics Series, Vol.32, Issue 1/2022, 78-99. (https://doi.org/10.2478/sues-2022-0005).
82. Neagu, O., Porumbăcean, T., Anghelina, A.M. (2023), Does financial development, globalisation and institutional quality drive the income convergence in the Central and Eastern European countries? Studia Universitatis Economics Series, "Vasile Goldiş" Western University of Arad, 33(1), 88-108. (https://doi.org/10.2478/sues-2023-0005).
83. OECD (2011), Towards Green Growth: Monitoring Progress. OECD indicators. Available at: https://www.oecd.org/greengrowth/48224574.pdf Accessed 15.09.2023
84. OECD (2023), Green Growth Indicators, Available at: https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH Accessed at: 5-th of September 2023.
85. Ofori, I., Figari, F. (2023), Economic globalisation and inclusive green growth in Africa: contingencies and policy-relevant threshold of governance, Sustainable Development, 31, 452-482. (https://doi.org/10.1002/sd.2403).
86. Özgüzer, G.E., Binatlı, A.O. (2016), Economic convergence in the EU: a complexity approach, Eastern European Economies 54, 93-108. (https://doi: 10.1080/00128775.2015.1126787).
87. Pata, U.K. (2020), Renewable and non-renewable energy consumption, economic complexity, CO2 emissions, and ecological footprint in the USA: Testing the EKC hypothesis with a structural break, Environmental Science and Pollution Research, 28, 846–861. (https://doi.org/10.1007/s11356-020-10446-3).
88. Patel, N., Mehta, D. (2023), The asymmetry effect of industrialization, financial development and globalization on CO2 emissions in India, International Journal of Thermofluids, Vol.20, 100397. (https://doi.org/10.1016/j.ijft.2023.100397).
89. Pelinescu, E. (2015), The impact of human capital on economic growth, Procedia Economics and Finance, 22, 184-190. (https://doi.org/10.1016/S2212-5671(15)00258-0).
90. Penn World Table (2023), PWT 10.01 (www.ggdc.net/pwt) (https://www.rug.nl/ggdc/productivity/pwt/?lang=en).
91. Pesaran, M.H., (2004), General Diagnostic Tests for Cross Section Dependence in Panels, Cambridge Working Papers in Economics No. 0435, University of Cambridge, Faculty of Economics: Cambridge, MA, USA. Available online: https://www.repository.cam.ac.uk/handle/1810/446 (Accessed on 2 September 2023).

92. Pesaran, M.H., (2007), A simple panel unit root test in the presence of cross-section dependence, Journal of Applied Econometrics 22: 265-312. (https://doi.org/ 10.1002/jae.951).
93. Poncet, S., de Waldemar, F.S. (2013), Economic complexity and growth. Evidence from China, Revue Économique, 64, 495–503. (https://doi.org/10.3917/reco.643.0495).
94. Potrafke, N. (2015), The evidence on globalisation, The World Economy, 38 (3), 509-552. (https://doi.org/10.1111/twec.12174)
95. Psacharopoulos, G. (1994), Return to investment in education: a global update, World Development, 22(9). 1325-1343. (https://doi.org/10.1016/0305-750X(94)90007-8).
96. Rahman, S. Chen, S., Saud, S., Bano, S., Haseeb, A. (2019), The nexus between financial development, globalization and environmental degradation: fresh evidence from Central and Eastern European countries, Environmental Science and Pollution Research, 26, 24733-24747. (https://doi.org/10.1007/s11356-019-05714-w).
97. Rafique, M.Z., Nadeem, A.M., Xia, W., Ikram, M., Shoaib, M., Shazhzad, U. (2021), Does economic complexity matter for environmental sustainability? Using ecological footprint as indicator, Environment, Developemnt and Sustainability, 24, 4623-4640. (https://doi.org/10.1007/s10668-021-01625-4).
98. Rahman, M.M., Alam K. (2022), Effects of corruption, technological innovation, globalisation, and renewable energy on carbon emissions in Asian countries, Utilities Policy, Vol.79, 101448, (https://doi.org/10.1016/j.jup.2022.101448).
99. Romero, J.P., Gramkow, C. (2021), Economic complexity and greenhouse gas emissions, World Development, 139, 105317. (https://doi.org/10.1016/j.worlddev.2020.105317).
100. Saidi, K., Omri, A. (2020), Reducing CO2 emissions in OECD countries: Do renewable and nuclear energy matter? Progress in Nuclear Energy, 126, 103425. (https://doi.org/10.1016/j.pnucene.2020.103425).
101. Sethi, P., Chakrabarti, D., Bhattacharjee, S. (2020), Globalization, financial development and economic growth: perils on the environmental sustainability of an emerging economy, Journal of Policy Modelling, Vol.42, issue 3, 520-535. (https://doi.org/10.1016/j.polmod.2020.01.007).
102. Shahbaz, M., Khan, S., Ali, A., Bhattacharya, M. (2017), The impact of globalization on CO2 emissions in China, The Singapore Economic Review, 62(04) pp.929-957. (https://doi.org/10.1142/S0217590817400331).
103. Shabaz, M., Shahzad, S.J.H., Mahalik, M.K. (2018a), Is globalisation detrimental to CO2 emissions in Japan, New threshold analysis, Environmental Modelling Assessment, 23, 557-568. (https://doi.org/10.1007/s10666-017-9684-0).
104. Shahbaz, M., Shahzad, S.J.H., Mahalik, M.K., Hammoudeh, S. (2018), Does globalization worsen environmental quality in developed economies? Environmental Modelling Assessment, 23, 141-156. (DOI 10.1007/s10666-017-9574-2).
105. Shahzad, U., Fareed, Z., Shahzad, F., Shahzad, K. (2021), Investigating the nexus between economic complexity, energy consumption and ecological footprint for the United States: New insights from quantile methods, Journal of Cleaner Production, 279, 123806. (https://doi. org/10.1016/j.jclepro.2020.123806).

106. Sheraz, M., Deyi, X., Mumtaz, M.Z., Ullah, A. (2022), Exploring the dynamic relationship between financial development, renewable energy, and carbon emissions: A new evidence from belt and road countries, Environmental Science and Pollution Research, 29, 14930-14947. (https://doi.org/10.1007/s11356-021-16641-0).
107. Simionescu, M., Strielkowski, W., Gavurova, B. (2022), A could quality of governance influence pollution? Evidence from the revised Environmental Kuznets Curve in Central and Eastern European Countries, Energy Reports, 8, 809-819. (https://doi.org/10.1016/j.egyr.2021.12.031).
108. Simionescu, M., Neagu, O., Gavurova, B. (2022b), The role of quality of governance in reducing pollution in Romania: an ARDL and nonparametric Bayesian approach, Frontiers in Environmental Science, 10, 892243. (https://doi.org/ 10.3389/fenvs.2022.892243).
109. Tacchella, A., Mazzilli, D., Pietronero, L. (2018), A dynamical systems approach to gross domestic product forecasting, Nature Physics, 14, 861–865. (https://doi.org/10.1038/s41567-018-0204-y).
110. Tahir, M., Hayat, A., Rashid, K., Afridi, M.A., Tariq, Y. B. (2020), Human capital and economic growth in OECD countries: some new insights, Journal of Economic and Administrative Sciences, 36(4), 367-380. (https://doi.org/10.1108/JEAS-07-2019-0073)
111. Tamura, R. (2004), Human capital and economic development, Federal Reserve Bank of Atlanta, Working Paper 34. (http://www.frbatlanta.org/filelegacydocs/wp0434.pdf).
112. Tawiah, V., Zakari, A., Adedoyin, F.F. (2021), Determinants of green growth in developed and developing countries, Environmental Science and Pollution Research, 28, 39227-39242. (https://doi.org/10.1007/s11356-021-13429-0).
113. Tian, Y., Li, L. (2022), Impact of financial inclusions and globalization on environmental quality: evidence from G20 countries, Environmental Science and Pollution Research, 29, 61265-61276. (https://doi.org/10.1007/s11356-022-19618-9).
114. Uddin, I., Ahmad, M., Ismailov, D., D., Balbaa, M.E., Akhmedov, A., Khasanov, S., Ul Haq, M. (2023), Enhancing institutional quality to boost economic development in developing nations: new insights from CS-ARDL approach, Research in Globalization, 7, 100137. (https://doi.org/10.1016/j.resglo.2023.100137).
115. Zafar, M. W., Zaidi, S. A. H., Khan, N. R., Mirza, F. M., Hou, F., & Kirmani, S. A. A. (2019), The impact of natural resources, human capital, and foreign direct investment on the eco-logical footprint: The case of the United States, Resources Policy, 63, 101–127. (https://doi.org/10.1016/j.resourpol.2019.101428).
116. Zhu, M. (2022), The role of human capital and environmental protection on the sustainable development goals: new evidence from Chinese economy, Economic Research, Vol.36, issue 1(https://doi.org/10.1080/1331677X.2022.2113334)
117. Wang, Z., Rasool, Y., Asghar, M.M., Wang, B. (2019), Dynamic linkages among CO2 emissions, human development, financial development, and globalization: empirical evidence based on PMG long-run panel estimation, Environmental Science and Pollution Research, 26,36248-36263. (https://doi.org/10.1007/s11356-019-06556-2).
118. Wirajing, M.A.K., Nchofoung, T.N., Etape, F.M. (2023), Revisiting the human capital-economic growth nexus in Africa, SN Business & Economics 3(7), 115. (https://doi.org/10.1007/s43546-023-00494-5).

119. Wolde-Rufael, Y., Weldemeskel, E.M. (2020), Environmental policy stringency, renewable energy consumption, and CO2 emissions: panel cointegration analysis for BRIICTS countries, International Journal of Green Energy, 17, 568–582. (https://doi.org/10.1080/15435075.2020.1779073)
120. World Bank Open Data (2023), (https://data.worldbank.org/)
121. Worldwide Governance Indicators (www.govindicators.org)
122. Wu, L., Adebayo, T.S., Yue, X.-G., Umut, A. (2022), The role of renewable energy consumption and financial development in environmental sustainability: implications for the Nordic Countries, International Journal of Sustainable Development & World Ecology, 30(1), 21-36. (https://doi.org/10.1080/13504509.2022.2115577).
123. Yldirim, A., Gökalp, M.F. (2016), Institutions and economic performance: a review on the developing countries, Procedia Economics and Finance 38, 347-359. (https://doi.org/10.1016/S2212-5671(16)30207-6).
124. You, W., Lv. Z. (2018), Spillover effects of economic globalization on CO2 emissions: A spatial panel approach, Energy Economics, Vol.73, June 2018, 248-257. (https://doi.org/10.1016/j.eneco.2018.05.016).

Appendix

Institutional quality index in CEE countries

	Bulgaria	Croatia	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovak Republic	Slovenia
1996	-2.509	-2.851	1.917	-2.293	1.635	-0.286	1.356	1.629	-0.343	-0.522	1.893
1997	0.514	-1.718	1.754	-0.625	1.701	-0.049	1.151	1.627	-0.909	-1.035	1.883
1998	1.182	-1.201	1.559	-0.031	1.763	0.142	0.892	1.625	-2.342	-2.148	1.873
1999	1.324	0.837	0.875	-0.033	1.755	-0.449	0.326	1.434	-0.877	0.360	1.534
2000	1.448	1.463	-3.109	-0.035	1.747	-2.096	-1.110	1.197	-0.306	1.011	1.018
2001	1.657	1.636	1.155	0.209	1.813	0.328	0.627	1.165	-0.218	1.041	1.226
2002	1.830	1.782	1.841	0.405	1.875	0.976	1.228	1.132	-0.137	1.071	1.399
2003	1.689	1.855	1.822	0.672	1.729	1.108	1.507	0.898	-1.099	1.420	1.360
2004	1.899	1.974	1.452	1.087	1.659	0.768	1.360	-0.423	0.464	1.803	1.352
2005	1.916	1.825	1.767	1.023	1.642	1.123	1.298	0.367	0.641	1.842	1.255
2006	1.697	1.819	1.872	1.335	1.745	1.411	1.252	-1.507	1.146	1.801	1.218
2007	1.733	1.846	1.750	1.337	1.576	1.294	1.247	0.259	1.033	1.559	1.261
2008	1.546	1.833	1.932	1.510	1.466	1.163	1.114	1.155	1.209	1.772	1.011
2009	1.811	1.866	1.930	1.446	1.176	1.287	1.233	1.405	1.067	1.717	1.066
2010	1.633	1.902	1.944	1.459	1.145	1.242	1.431	1.635	1.217	1.662	0.720
2011	1.394	1.887	2.000	1.541	1.163	1.183	1.219	1.673	1.110	1.732	0.887
2012	1.454	1.917	1.862	1.471	0.853	1.356	1.659	1.780	0.895	1.605	0.261

2013	1.228	1.964	1.889	1.491	0.917	1.490	1.756	1.755	1.303	1.446	-0.215
2014	1.333	1.966	1.993	1.757	0.069	1.715	1.858	1.858	1.543	1.543	-0.114
2015	1.344	1.890	2.061	1.832	-0.167	1.768	2.000	1.811	1.594	1.503	0.151
2016	1.591	1.932	1.975	1.817	-3.214	1.713	1.983	1.401	1.665	1.724	0.260
2017	1.725	1.950	2.062	1.823	-0.005	1.720	1.886	0.966	1.677	1.429	-0.530
2018	1.726	2.003	1.973	1.851	-0.567	1.672	1.726	0.823	1.471	1.328	-0.053
2019	1.844	1.987	1.937	1.870	-1.293	1.858	1.967	0.890	1.483	1.477	0.744
2020	1.161	1.944	2.022	1.894	-0.659	1.894	2.010	0.499	1.557	1.563	-0.357

Source: authors' computation using PCA method in EViews 12.0