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RESEARCH ARTICLE

Impact of globalization, institutional quality, economic growth, electricity and renewable energy consumption on Carbon Dioxide Emission in OECD countries

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Abstract

This research for the first time examines the influence of the financial development, stock market, globalization, institutional quality, economic growth, electricity, and renewable energy consumption on carbon dioxide emission from 1985 to 2018 in thirty-six (OECD) countries. Cointegrations exist in the used variables based on the examined findings of the Kao, Westerlund, and Pedroni cointegration. Findings of the pooled mean group (PMG) indicate that renewable energy consumption, globalization, and institutional quality assist to reduce the carbon dioxide emission that improve the environment while financial development, stock market, electricity consumption, and economic growth cause to increase the carbon dioxide emission in OECD countries both in the long and in the short run. To reduce carbon dioxide emission, important policy implications are suggested for OECD countries.

Keywords Financial development · Stock market · Economic growth · Institutional quality · Globalization

Abbreviations

CO2e	Carbon dioxide emission
INSTQ	Institutional quality
EGT	Economic growth
EC	Energy consumption
ARDL	Autoregressive distributed lag
ELEC	Electricity consumption
FD	Financial development
GLB	Globalization

Introduction

Greenhouse gases are known main CO2e element that causes natural disasters around the world. Chishti et al. (2021), Muhammad et al. (2021), and Khan et al. (2019a, 2019b) demonstrated that degradation of environment is chiefly caused

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by forest fire and floods that causes disaster and adversely influences the world by affecting the infrastructure, natural resources, agriculture land, and human's beings. In a recent report, the OECD (2020) indicated that CO2e is the main element of the greenhouse gases around the world. As per report issued by the OECD (2020), Canada is ranked as the CO2e-emitting country that is followed by Australia, USA, and Luxembourg. Canada produces 15.5%, Australia produces 15.3%, USA produces 14.9%, and finally Luxembourg produces 14.8% CO2e tonnes/per capita that is increasing day by day.

Sarkodie and Adams (2018) in South African countries examined the impression of the energy ingesting and INSTQ on CO2e. The results revealed that the environment in South African states improves with INSTQ. Salman et al. (2019) studied the impacts of the INSTQ on CO2e. The results indicated that CO2e is positively impacted by the INSTQ. Based on the investigated findings, the authors revealed that effectiveness institutes are important elements of regulations that will assist to decrease the CO2e and increase the EGT. Abid (2016) revealed that CO2e is negatively impacted by the increase in the INSTQ. Hassan et al. (2019) conducted a research study in Pakistan to examine the impression of the INSTQ on the CO2e. The findings indicated that CO2e is positively impacted by the INSTQ. Asongu and Odhiambo (2019) indicated that adoption of environment-related laws helps to reduce the CO2e and improve the quality of the atmosphere.

Sarkodie et al. (2020) revealed that REC assists in dipping the CO2e in African economies. Wang et al. (2018) demonstrated that REC assists the health facilities, education, and gender gap by improving the environment. Daly et al. (2019), Hossain et al. (2013), and Destek and Aslan (2020) conducted a study in G-7 countries to examine the impacts of REC on CO2e. Based on the examined findings, the authors indicated that biomass EC decrease the CO2e. In Pakistan, Khan et al. (2019b) examined the impact of EC on CO2e. The findings revealed that CO2e is positively influenced by the EC. In another recent study by the same authors in Pakistan, Khan et al. (2020) indicated that CO2e is positively associated with the EC and EGT. Munir et al. (2020) conducted research in Asian countries to examine the impact of EGT on the CO2e. The findings revealed that CO2e is positively impacted by the EGT in Asian countries. Adedoyin et al. (2020) conducted research to examine the influence of coal consumption and EGT CO2e in BRICS (Brazil, Russia, India, China, and South Africa) countries. The results indicated that EGT and coal consumption have positive impact on the CO2e in BRICS countries. Cowan et al. (2014), Odhiambo (2010), Apergis and Payne (2010), Akinlo (2008), and Yoo (2006) conducted different research studies to examine the impact of EC and EGT on the CO2e. The findings indicated that EC causes to boost the CO2e. In African economies, the authors Awodumi and Adewuyi (2020) examined the impact of EC on the CO2e by applying the non-linear autoregressive distributed lag. The examined results demonstrated that EC has a positive impact on the CO2e. Salahuddin and Gow (2019) examined the impact of ELEC, EGT, and foreign direct investment on the CO2e in Kuwait. The findings indicated that EGT, electricity, and FDI positively impact the CO2e. In another study by the same authors, Salahuddin et al. (2015) conducted the impact of ELEC on the CO2e. The findings indicated that the use of electricity for industrial use and EGT has a positive impact on the CO2e in GCC. Early researches calculated the FD by using different proxies' domestic credit to private sector (Sadorsky, 2011; Shahbaz et al., 2015, 2019). Few researches used stock market variables to indicate the FD (Abbasi and Riaz, 2016).

Shahbaz et al. (2017) applied time series data for China from 1970 to 2012 to examine the impact of GLB on CO2e to verify the existence of environmental Kuznets curve (EKC). They indicated that GLB positively impact the CO2e that is caused by high consumption that developed countries shift to the developing countries; developing countries of the world for the purpose of economy growth accept the problem of CO2e. Mishkin (2009) demonstrated that all people around the world are impacted by the GLB elements i.e. economic, political, and social. Developing countries of the world are associated with the developed countries for the fund inflow for the purpose of EGT. Khan et al. (2019a) in Pakistan examined the impact of GLB on CO2e by utilizing time series data. The investigated findings indicate that GLB has positive effect on CO2e; they further stated that developed countries are investing in Pakistan due to stabilize and growing investment opportunities for international investors; for the sake of economic development, the emission of carbon is increasing continuously.

Early research studies investigated the most widely used variables that impact the carbon dioxide emission; but these research studies only inspected the impacts of globalization or institutional quality with other economic variables and economic growth on carbon dioxide emission but still the research gap exists by including financial development, stock market, globalization, institutional quality, electricity consumption, renewable energy consumption, and economic growth that is totally ignored in the early research studies. Panel data for 36 OECD countries (see Appendix Table 10) for the time period from 1985 to 2018 were applied for the first time. The main objective of this research is to investigate the impact of financial development, stock market, globalization, institutional quality, economic growth, electricity consumption, and energy consumption on carbon dioxide emission. The studied countries are chosen based on the economic growth, high for energy to achieve the economic activities; due to high energy consumption, pollution is the main problem of these countries that produce anxiety among the policymakers and energy experts. This study used updated dataset and applied pooled mean group ARDL approach for result analysis suggested by Pesaran et al. (1999). Additionally, this research used cross-sectional

dependency test (Pesaran 2004), Westerlund cointegration (Westerlund 2005), Kao cointegration (Kao 1999), and Pedroni cointegration (Pedroni 1999, 2004) respectively.

Literature review

Ahmad et al. (2021) examined the interaction among the sustainable investment, environmental degradation, and sustainable development in Chinese economy at provincial level by using GMM approach for result estimation. The examined findings demonstrate that sustainable investment and development help to improve the environmental. Ozturk et al. (2021) investigated the decoupling and decomposition examination of the environmental influence from the economy development in China, India, and Pakistan. The findings of the examined study demonstrated that Pakistan and China face negative decoupling while India faces weak decoupling. Ozturk (2017) indicated that nuclear energy consumption, fossil fuel energy consumption, and carbon dioxide emission positively impact the economy growth in the Latin American states while the prices of oil have no impact on the economy growth. Chandio et al. (2020) examined the influence of the crop production, livestock production, power consumption in agriculture, and forest area on the carbon dioxide (CO2) emissions in China. They indicated that crop production and livestock production significantly and positively impact the carbon dioxide emission in China while energy consumption in the agriculture sector and forest area helps to reduce the carbon dioxide emission. Chandio et al. (2021) demonstrated that renewable energy consumption and forest help to decrease the environmental degradation in China while non-renewable energy resource consumption, economy growth, and agriculture production cause to increase the environmental degradation in China.

In South America, the author Hdom (2019) studied the impact of electricity production on CO2e by utilizing the ARDL model over the period 1980 to 2010. The examined findings indicate that electricity production and EGT in the short run have positive relation with the CO2e while REC helps to reduce the pollution in South America. The author advised that South American should use REC to reduce the CO2e. Ridhosari and Rahman (2020) indicated that ELEC is considered the main factor that positively impacts the CO2e. Hamdi et al. (2014) examined the association of ELEC and FDI with EGT. The examined findings indicated that ELEC and EGT have relationship in Bahrain. Liddle and Sadorsky (2017) investigated the impacts of electricity production on CO2e. The examined findings indicated that 1% growth in electricity production causes to diminish the CO2e about 0.82%. Cowan et al. (2014) examined the impacts of ELEC on CO2e. The findings demonstrated that ELEC causes Granger causality CO2e.

Ibrahim and Law (2016) examined the influence of INSTQ on CO2e in African countries. The findings show that INSTQ assists in CO2e reduction in the African countries. The examined findings further demonstrated that trade openness has a positive impact on the CO2e. Another study by the same authors Ibrahim and Law (2014) demonstrated that INSTQ play a key role to improve the quality of environment and INSTQ is considered a remedy for clean environment. Abid (2016) examined the influence of INSTQ on the CO2e in African countries. The findings indicated that INSTQ helps to reduce the CO2e; based on the findings, they revealed that rules associated with law help to improve the environment.

Liu et al. (2020) in G-7 economies examined the impact of GLB to verify the EKC hypothesis. The findings indicated that GLB assists to verify the existence of EKC hypothesis in G-7 economies. Furthermore, the examined findings demonstrated that EGT has positive and significant impact while the REC has a negative impact on the CO2e. Shujah Ur et al. (2019) investigated the impacts of GLB, EC, and REC on the CO2e. The findings demonstrated that GLB and REC help to reduce the CO2e while adversely influence the degradation of environment while traditional EC causes to increase the CO2e. Zaidi et al. (2019) investigated the influence of GLB on the CO2e in the Asia–Pacific Economic Cooperation. The examined findings indicated that GLB help to reduce the CO2e. Saint Akadiri et al. (2019) examined the influence of GLB on the CO2e in Turkey. The findings demonstrated that GLB helps to reduce the CO2e in Turkey.

Hu et al. (2018) examined the influence of REC on the CO2e. The findings demonstrated that REC helps to decrease the CO2e. Sarkodie and Adams (2018) examined the impacts of INSTQ, EC, and REC on the CO2e in South African countries. The findings revealed that REC and INSTQ help to reduce the CO2e in South African economies. Riti et al. (2017) investigated the impacts of FD, population, and REC. The findings demonstrated that FD, population, and REC have negative impacts on the CO2e while the findings of traditional EC cause to increase the CO2e. Liu et al. (2017) examined the impact of REC and agricultural value-added production on CO2e in Asian economies. The examined findings demonstrated that REC and agricultural value-added production assist to reduce the CO2e in Asian economies while the finding of traditional EC indicates positive influence on the CO2e.

Research methodology and data source

This study purposes to examine the impacts of economic growth, REC and ELEC, globalizations, and institutional quality on the CO2e in thirty-six (36) OECD countries by utilizing balanced panel dataset for the time period from

Table 1 Variables description

Variables	Expected results	Description	Data source
Carbon dioxide emission		Metric tons/capita	OECD
Stock market	Positive	Share prices	OECD
Financial development	Positive	Domestic credit to private sectors	OECD
Renewable energy consumption	Negative	Total percentage of primary energy	OECD
Electricity consumption	Positive	Total gigawatt-hours	OECD
Economic growth	Positive	GDP (Constant 2010 USD)	WDI
Institutional quality	Negative	Government stability, democratic accountability, bureaucratic quality, corruption, and finally law and order	ICRG
Globalization	Negative	KOFI globalization index	KOFI

1985 to 2018 for result analysis. This research followed recent published research for variable selection. Chishti et al. (2021), Muhammad et al. (20,121), Khan et al. (2019a, b), and Khan et al. (2020a, b) used CO2e as a proxy for measuring CO2e; Muhammad et al. (2021), Sarkodie et al. (2020), and Destek and Aslan (2020) used REC to examine the impact on the CO2e; Teng et al. (2020), Hamdi et al. (2014), Hdom (2019), Liddle and Sadorsky (2017), and Ridhosari and Rahman (2020) used ELEC as a main indicator for CO2e; Khan et al. (2019a, b), Khan et al. (2020), Salahuddin and Gow (2019), Awodumi and Adewuyi (2020), and Teng et al. (2020) examined the impact of economic growth on the CO2e; Khan et al. 2019a), Ibrahim and Law (2016), Abid (2016), Ibrahim and Law (2014), and Teng et al. (2020) for institutional quality; Khan et al. (2019a), Mishkin (2009), Shahbaz et al. (2017), and Teng et al. (2020) for globalization and CO2e; Samour et al. (2019) and Zafar et al. (2019) for financial development, stock market, and CO2e. This analysis derives and initiates the following basic equation.

Table 2 Descriptive statistics

Variable	Obs	Mean	Std. Dev	Min	Max
Carbon dioxide emission	1224	0.921	0.207	0.240	1.509
Financial development	1224	50.492	34.546	0.438	546.675
Stock market	1224	71.316	61.662	0.000	657.822
Renewable energy consumption	1224	13.905	15.571	0.110	89.750
Electricity consumption	1224	4.862	0.682	2.955	6.622
Economic growth	1224	2.702	3.156	− 14.814	25.163
Institutional quality	1224	1.707	1.677	2.205	6.089
Globalization	1224	1.871	0.073	1.591	1.961

$$\begin{aligned}\text{Carbon Dioxide Emission}_{it} &= \beta_0 + \beta_1 \text{Renawable Energy Consumption}_{it} \\ &+ \beta_2 \text{Electricity Consumption}_{it} + \beta_3 \text{Economic Growth}_{it} \\ &+ \beta_4 \text{Institutional Quality}_{it} + \beta_5 \text{Globalization}_{it} \\ &+ \beta_6 \text{Stock Market}_{it} + \beta_7 \text{Financial Development}_{it} + \varepsilon_{it}\end{aligned} \quad (1)$$

Table 3 Correlations matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Carbon dioxide emission	1.000							
Renewable energy consumption	-0.218	1.000						
Electricity consumption	0.156	-0.244	1.000					
Economic Growth	-0.041	-0.012	-0.089	1.000				
Institutional Quality	0.455	0.249	0.036	-0.084	1.000			
Globalization	0.249	0.045	0.217	-0.060	0.470	1.000		
Stock Market	0.543	0.523	-0.673	0.076	0.291	0.598	1.000	
Financial Development	0.872	0.524	0.892	0.123	0.453	0.234	0.879	1.000

In the above, t indicates the time period from 1985 to 2018 and i indicates the thirty-six (36) OECD countries. CO2e is used as dependent variable while stock market, REC, ELEC, economic growth, institutional quality, and globalization as independent variables. Table 1 demonstrates the detailed description of variables.

Panel ARDL

This study used balanced panel data for result analysis for 34 years that is shown by $t = 1,2,3,4,\ldots\ldots\ldots..34$ and groups of thirty-six countries indicated by $i = 1,2,3,4,\ldots\ldots\ldots..36$. The following basic form of panel ARDL (P, Q, Q……,Q1) model is estimated.

$$\text{Carbon Dioxide Emission}_{it} = \sum_{j=1}^{P} \lambda_{ij}\text{Carbon Dioxide Emission}_{it-j} + \sum_{j=0}^{Q} \delta'_{ij} X_{it-j} + \mu_i + \varepsilon_{it} \tag{2}$$

In the above Eq. 2, $X_{it}(kx1)$ indicates the vectors of the regressors (REC, ELEC, economic growth, institutional quality, financial development, stock market, and globalization). $i;\mu_i$ demonstrate the fixed effect and the coefficients of the lagged regressand i.e. CO2e, λ_{ij} demonstrate the scalars, and finally the δ_{ij} indicates the $(kx1)$ coefficient vector. If cointegration exists in the dependent variable and the independent variables, the error correction terms are applied. Based on the characteristics of cointegration in the used variables, response to the deviation is caused by the long-term equilibrium. This characteristic of used variables shows the error correction model that identify the short-run dynamics of dependent and independent variables respectively in the equation that is the deviation from the equilibrium. The following error correction equation is derived based on Eq. 2.

$$\begin{aligned}\Delta\text{CarbonDioxideEmission}_{it} = {} & \varnothing_i\left(\text{Carbon Dioxide Emission}_{it-1} - \theta'_i X_{it}\right) \\ & + \sum_{j=1}^{P-1} \lambda^*_{ij}\Delta\text{Carbon Dioxide Emission}_{it-1} \\ & + \sum_{j=0}^{Q-1} \delta'^*_{ij}\Delta X_{it-j} + \mu_i + \varepsilon_{it}\end{aligned} \tag{3}$$

$$\varnothing_i = -\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right), \theta_i = \sum_{j=0}^{Q} \frac{\delta_{ij}}{\left(1-\sum_i \lambda_{ik}\right)}, \lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im} j = 1,2,3,\ldots., P-1, \text{and} \delta^*_{ij} = -\sum_{m=j+1}^{Q} \delta_{im} j = 1,2,3,\ldots., Q-1.$$

In Eq. 3, $\varnothing_i$ in Eq. 3 demonstrate the speed of adjustment. If the examined results of the error correction term i.e.$\varnothing_i = 0$, no long-run relationship exists in the dependent and the independent variables . The error correction term to be significant and negative grounded on hypothesis that is applied for the used variables in the equation that show the long-run equilibrium while the term θ'_i in Eq. 3 demonstrates the long-run relation in the dependent and the independent variables respectively.

$$\begin{aligned}\Delta\text{Carbon Dioxide Emission}_{it} = {} & \beta_0 + \varnothing_{1,i} \\ & \left[\text{Carbon Dioxide Emission}_{it-1} - \theta'_{2,i}(\text{Renewable Energy Consumption}_{it} + \text{Electricity Consumption}_{it} + \text{Economic Growth}_{it} + \text{Institutional Quality}_{it} + \text{Globalization}_{it} + \text{Stockmarket}_{it} + \text{Financial Development}_{it})\right] \\ & + \sum_{j=1}^{P-1} \lambda^*_{ij}\Delta\text{Carbon Dioxide Emission}_{it-1} \\ & + \sum_{j=0}^{Q-1} \delta'^*_{ij}\Delta\text{Renewable Energy Consumption}_{it-j} \\ & + \sum_{j=0}^{Q-1} \delta^*_{ij}\Delta\text{Electricity Consumption}_{it-j} \\ & + \sum_{j=0}^{Q-1} \delta^*_{ij}\Delta\text{Economic Growth}_{it-j} \\ & + \sum_{j=0}^{Q-1} \delta^*_{ij}\Delta\text{Institutional Quality}_{it-j} + \sum_{j=0}^{Q-1} \delta'^*_{ij}\Delta\text{Globalization}_{it-j} \\ & + \sum_{j=0}^{Q-1} \delta^*_{ij}\Delta\text{Stockmarket}_{it-j} \\ & + \sum_{j=0}^{Q-1} \delta'^*_{ij}\Delta\text{Financial Development}_{it-j} + \mu_i + \varepsilon_{it}\end{aligned} \tag{4}$$

Table 4 Variance inflation factor (VIF)

Variables	VIF	1/VIF
Institutional quality	1.382	0.723
Stock market	1.534	0.651
Financial development	1.763	0.567
Globalization	1.355	0.738
Renewable energy consumption	1.145	0.873
Electricity consumption	1.134	0.882
Economic growth	1.015	0.985
Mean VIF	1.332	

Table 6 Cross-sectional dependence test

Variable	CD test	*p*-value	Corr	Abs (corr)
Carbon dioxide emission	30.10	0.000	0.206	0.529
Stock market	29.99	0.000	0.198	0.512
Financial development	54.34	0.000	0.345	0.439
Renewable energy consumption	59.38	0.000	0.406	0.570
Electricity consumption	91.42	0.000	0.625	0.724
Economic growth	54.52	0.000	0.373	0.387
Institutional quality	22.89	0.000	0.156	0.386
Globalization	140.97	0.000	0.963	0.963

Pesaran and Smith (1995) suggested the mean group (MG) estimator in which all the used intercept, slopes of the confidents of the variables, and finally the error variation are heterogeneous across the countries. Pesaran et al. (1997, 1999) suggested the pooled mean group (PMG) estimator that related both the average and the pool characteristics respectively. Pooled mean group estimator allows the intercepts, and the coefficients of the short run and the error variations are not the same across the countries while in the long run, the coefficients are similar in countries.

This research investigated the dependency in cross section with Pesaran CD test (Pesaran 2004). Additionally, stationarity were examined with Harris-Tzavalis test and Levin-Lin-Chu test (Tzavalis 1999 and Levin et al. 2002 respectively). Cointegration was inspected with the Westerlund, Kao, and Pedroni cointegration tests proposed by Westerlund (2005), Kao (1999), and Pedroni (1999, 2004) respectively. To select among the pooled mean group and mean group estimator, Hausman test was suggested by Hausman (1978).

Results and discussions

Table 2 results indicate that the mean of CO2e is 0.921 with the maximum and minimum values 1.509 and 0.240 respectively. The mean value of stock market is 71.316 while the maximum value is 657.822 and the mean value of financial development is 50.234. The findings of REC minimum and maximum values are 0.110 and 89.750 respectively. The findings of the descriptive statistics indicate that the mean value of ELEC is 4.862 while the minimum and the maximum values are 2.955 and 6.622 respectively. The minimum and maximum values of the economic growth are 14.814 and 25.163 respectively. The institutional quality results indicate that the mean value is 1.707 while the mean value of the globalization is 1.871 with maximum and minimum values 1.961 and 1.591 respectively.

Table 3 is used to examine the correlation in the used variables. The examined findings indicate that CO2e have positive relationship with ELEC, institutional quality, and globalization while negative relationship with REC and economic growth. Stock market and financial development

Table 5 Panel unit root tests

	Levin-Lin-Chu		Harris-Tzavalis	
	At level	At difference	At level	At difference
Carbon dioxide emission	−1.5639*	−12.3001***	0.3272	−56.4886***
Stock market	−1.5494*	−13.2134***	0.5453	−50.5465***
Financial development	−1.6583*	−11.3421**	0.6497	−55.6784***
Renewable energy consumption	6.4502	−6.3990***	−5.6107***	−63.9367***
Electricity consumption	−10.9640***	−14.1242***	1.6612	−60.1172***
Economic growth	−12.2422***	−26.9235***	−33.2265***	−75.5538***
Institutional quality	−4.9080***	−16.3483***	−4.3395**	−48.9070***
Globalization	−9.3795***	−11.2080***	3.1026	−44.2782***

*$p < 0.05$
**$p < 0.01$
***$p < 0.001$

Table 7 Panel cointegration tests

Kao cointegration test		
	Statistic	*p*-value
Modified Dickey-Fuller *t*	−1.9833	0.0237
Dickey-Fuller *t*	−2.2548	0.0121
Augmented Dickey-Fuller *t*	−1.3917	0.0820
Unadjusted modified Dickey-Fuller *t*	−2.7880	0.0027
Unadjusted Dickey-Fuller *t*	−2.6865	0.0036
Pedroni cointegration test		
	Statistic	*p*-value
Modified Phillips-Perron *t*	3.7781	0.0001
Phillips-Perron *t*	−1.7169	0.0430
Augmented Dickey-Fuller *t*	−0.9875	0.1617
Westerlund cointegration test		
	Statistic	*p*-value
Variance ratio	2.6778	0.0037

Table 8 Pooled mean group estimators

Long-run coefficients				
Variable	Coef	Std. Err	*Z*	*p*-value
Stock market	0.8599	0.4663	1.8441	0.0736
Financial development	0.4569	0.1209	3.7791	00,005
Renewable energy consumption	-0.6547	0.1746	−3.7500	0.0000
Electricity consumption	0.9537	0.4663	1.4300	0.0482
Economic growth	0.2160	0.0328	6.6000	0.0000
Institutional quality	0.2599	0.1030	1.5500	0.0162
Globalization	−0.3094	0.1590	−1.9500	0.0520
Short-run coefficients				
ECT(-1)	−0.7908	0.0948	−8.3400	0.0000
Stock market	0.5996	0.2663	2.2516	0.0307
Financial development	0.3931	0.1598	2.4912	0.0176
Renewable energy consumption	−0.4365	0.1373	−3.1800	0.0010
Electricity consumption	0.4114	0.0567	7.2600	0.0000
Economic growth	0.1740	0.0223	0.7800	0.0000
Institutional quality	−0.2155	0.0513	−4.1986	0.0000
Globalization	−0.2889	0.1088	−2.6535	0.0030
Constant	0.0850	0.0120	7.0800	0.0000
Hausman chi^2	6.1509	*p*-value		0.5113

indicate positive relation with CO2es, EC, and economic growth.

Table 4 demonstrates the finding of variance inflation factor problem of multicollinearity in the used variables. The examined findings demonstrate that no multicollinearity problem exists in used variables based on VIF results. The findings of the tolerance values indicate that all variables are greater than 0.20 and the VIF values are less than 5 that show that no multicollinearity exists in variables.

Table 5 is used to demonstrate the findings of the panel unit root test. The examined findings of Levin-Lin-Chu unit root test indicate that financial development, stock market, CO2e, ELEC, economic growth, institutional quality, and globalization have no unit root issue at level and first difference while REC is not stationary at level but stationary at first difference. On the other hand, the results of the Harris-Tzavalis unit root test indicate that stock market, CO2e, ELEC, and globalization are not stationary at level but these variables become stationary at first difference while REC, economic growth, and institutional quality are stationary at level and at first difference.

Table 6 demonstrates the findings of the cross-sectional dependency. The examined results of the cross-sectional dependence test indicate that the used variables are stationary that reject the H0. The result of the cross-sectional dependency test demonstrates that cross-sectional dependency exists in all countries.

Table 7 demonstrates the results of Westerlund, Kao, and Pedroni cointegration tests respectively. The inspected results of Westerlund, Kao, and Pedroni cointegration test indicate cointegration in the used variables. The results show that Westerlund, Kao, and Pedroni cointegrations are significant that demonstrate cointegration in the study variables.

Table 8 shows the result of pooled mean group estimators. The findings of stock market and financial development indicate positive and significant influence on the CO2e in OECD economies. The findings indicate that increase in stock market and financial development in the OECD countries causes to increase the CO2e. The findings of stock market and CO2e are similar with Zafar et al. (2019) and Khan et al. (2021). Khan et al. (2021) and Zafar et al. (2019) indicated that financial development and stock market cause to increase the CO2e.

The inspected results of REC demonstrate negative and significant impact on the CO2e in OECD countries. The findings reveal that the use of REC assists in CO2e reduction in OECD countries both in the long run and in the short run. The inspected findings demonstrate that increase in REC helps to reduce the CO2e about 0.65% and 0.45% respectively both in the long run and in the short run. Findings of the REC are the same with early research. Muhammad et al. (2021) investigated the impact of REC on CO2es around the world. They indicated that REC assists to reduce the CO2e. Teng et al. (2020) examined the influence of REC on CO2e. The examined findings demonstrate that REC helps in CO2e reduction. Usman et al. (2020) examined asymmetrical influence of EC on CO2e in Pakistan by using time series data. They demonstrated that clean EC helps to reduce the CO2e in Pakistan. Bento and Moutinho (2016), Chiu and Chang (2009), Al-Mulali et al. (2015), and Shafiei and

Salim (2014) studied the influence of REC on CO2e. They indicated that REC assist to decrease the CO2e. Dogan and Seker (2016) examined the causes of CO2e. The examined findings demonstrate that REC assists to diminish the CO2e while the use of traditional EC causes to increase the CO2e. Jebli and Youssef (2015) investigated the influence of REC on the CO2e. The findings demonstrate that REC helps to reduce the CO2e.

The investigated results of ELEC indicate positive and significant influence on the CO2e both in the long run and in the short run. The examined results of the ELEC indicate that 1% increase has a positive impact on the CO2e and causes to boost the CO2e about 0.95% and 0.41% respectively both in the long run and in the short run. Findings of the ELEC are the same with the following authors. Asongu et al. (2020) scrutinized the influence of ELEC and urbanization on CO2e in a group of countries. The findings demonstrate that ELEC has positive impacts on the CO2e. Rahman (2020) stated that ELEC boost the CO2e that causes CO2e. In South Asian economies, the authors Munir and Riaz (2020) investigated the asymmetrical impact of ELEC on CO2e. The findings demonstrated that ELEC has positive impacts on the CO2e in South Asian economies. Similar findings were suggested by Salahuddin et al. (2018). They indicated that ELEC causes to increase the pollution.

Findings of the economic growth indicate positive and significant impacts on the CO2e in OECD countries both in the long and short run. The investigated findings of pooled mean group indicate that 1% growth in economic growth causes to boost the CO2es about 0.21% and 0.17% respectively both in the long run and in the short run in thirty-six OECD countries. Findings of economic growth and CO2e are in-line with previously published researches. Muhammad et al. (2021) demonstrated that economic growth around the world causes CO2es. Another recent study by Teng et al. (2020) and Khan et al. (2020) stated that CO2es are positively influenced by the economic activities. In Pakistan, Khan et al. (2019a, b) applied dynamic ARDL simulation time series model and demonstrated that carbon dioxide is positively impacted by the economic activities. Alvarado et al. (2018) indicated that economic activities cause to increase the CO2e; they further indicated that EKC is effective for the developed economies of the world.

Table 9 Diagnostic tests

Test	Calculated value	Prob
Breusch-Pagan/Cook-Weisberg test	3.01	0.9040
Ramsey RESET test	2.60	0.0931
Wooldridge test	4.64	0.8290

Findings of the institutional quality in the long run demonstrate positive impact while in the short run, institutional quality has negative and significant impacts on the CO2e in thirty-six OECD countries. Pooled mean group (PMG) findings indicate that 1% increase in institutional quality in the long run causes to increase the carbon emission about 0.25% increase and in the short run, institutional quality assists to reduce the carbon emission about 0.21%. Ibrahim and Rahman (2015) demonstrated that institutional quality improves the rules and regulations that help to reduce the CO2e. Ali et al. (2019) demonstrated that CO2es are negatively impacted by the institutional quality. Lau et al. (2014), Tamazian and Rao (2010), and Al-mulali and Ozturk (2015) indicated that institutional quality helps to reduce the CO2e. Bhattacharya et al. (2017) demonstrated that institutional quality has positive impacts on the economic growth while CO2e is negatively impacted by the institutional quality.

The investigated findings of globalization demonstrated negative and significant effect on the CO2e in OECD countries both in the long and in the short run. Findings of the globalization indicate that 1% increase in globalization both in the long and in the short run helps to reduce the CO2e about 0.30% and 0.28% respectively. Teng et al. (2020) demonstrated that in the long run, globalization has negative impacts on the CO2e. Balsalobre-Lorente et al. (2019) demonstrated that globalization helps to reduce the CO2e. Shahbaz et al. (2019) revealed that CO2e decreases with increase in globalization. In Pakistan, the authors Khan et al. (2019a) demonstrated that CO2e increases with globalization. Xu et al. (2018) and Twerefou et al. (2017) demonstrated that globalization causes to increase CO2e. Findings of the error correction term indicate that the convergence speed from the disequilibrium is about 0.79%.

Table 9 demonstrates the finding of different diagnostic tests for the used model. The investigated results and Breusch-Pagan/Cook-Weisberg test demonstrate that no problem of heteroscedasticity exists in the applied model. The findings of Ramsey RESET test indicate that no specification error problem exists in the model. Finally, the findings of Wooldridge test indicate that no problem of autocorrelation exists.

Conclusion

This study examined the impact of financial development, stock market, globalization, institutional quality, REC, economic growth, and ELEC on CO2e in thirty-six OECD countries with a balanced panel data from 1985 to 2018. Panel ARDL model is applied to examine the relationship in the study variables. Stationarity of the variables are examined with panel unit root tests i.e. Harris-Tzavalis test and Levin-Lin-Chu test respectively. The findings of the panel

unit root test indicate that the variables are stationary at level and at first difference respectively. Based on the stationarity of the used variables, panel ARDL can be applied. Westerlund, Kao, and Pedroni cointegration tests are used to examine the cointegration in the used variables. The findings of the Westerlund, Kao, and Pedroni cointegration tests indicate that cointegration exists in the study variables. Hausman test is used to select between the pooled mean group (PMG) estimator and mean group (MG) estimator. The examined findings of the Hausman test indicate that pooled mean group estimator is suitable as compared to the mean group estimator.

The inspected results of REC demonstrate negative and significant impact on the CO2e in OECD countries. The findings reveal that the use of REC assists in CO2e reduction in OECD countries both in the long run and in the short run. The inspected findings demonstrate that increase in REC helps to reduce the CO2e about 0.65% and 0.45% respectively both in the long run and in the short run. The investigated results of ELEC indicate positive and significant influence on the CO2e both in the long run and in the short run. The examined results of the ELEC indicate that 1% increase has a positive impact on the CO2e and causes to boost the CO2e about 0.95% and 0.41% respectively both in the long run and in the short run. Findings of the economic growth indicate positive and significant impacts on the CO2e in OECD countries both in the long and short run. The investigated findings of pooled mean group indicate that 1% growth in economic growth causes to boost the CO2es about 0.21% and 0.17% respectively both in the long run and in the short run in thirty-six OECD countries. Findings of the institutional quality in the long run demonstrate positive impacts while in the short run, institutional quality has negative and significant impacts on the CO2e in thirty-six OECD countries. Pooled mean group (PMG) findings indicate that 1% increase in institutional quality in the long run causes to increase the carbon emission about 0.25% increase and in the short run, institutional quality assists to reduce the carbon emission about 0.21%. The investigated findings of globalization demonstrated negative and significant effect on the CO2e in OECD countries both in the long and in the short run. Findings of the globalization indicate that 1% increase in globalization both in the long and in the short run helps to reduce the CO2e about 0.30% and 0.28% respectively. Financial development and stock market results indicate positive impact on CO2e both in the long and in the short run respectively. Additionally, this study used different diagnostic tests. The investigated results of the Breusch-Pagan/Cook-Weisberg test demonstrate that no problem of heteroscedasticity exists in the applied model. The findings of Ramsey RESET test indicate that no specification error problem exists in the model. Finally, the findings of Wooldridge test indicate that no problem of autocorrelation exists.

It is observed based on the examined findings of this research that the chief elements of CO2e in the OECD countries are ELEC for economic activities; to compete with the developed countries of the world, OECD countries are trying to maintain the economic growth by using different energy resources that causes to boost the CO2e and increase the CO2e. To compete with the economic challenges and achieve the sustainable development goals, the policymakers need to suggest policies that promote the sustainable environment by following sustainable development goals. The OECD countries need to improve public–private partnership in different energy projects for clean environment by following the goals 6 and 7 (SDGs) for affordable and clean energy, clean water, and sanitation. Urbanization is continuously increasing in OECD countries that cause to increase the demand for EC; for economic activities, the use of fossil fuels creates positive impacts of the CO2e in OECD countries. By achieving the SDGs 7 by 2030 of the OECD countries, policymaker needs to promote and encourage investment in solar, wind, and thermal power, to improve the clean energy productivity, and ensure clean energy for all that will expand the infrastructure and upgrade the technology-based clean and efficient energy resources in all OECD countries and will achieve the economic growth and clean environment. The government of OECD countries should promote rules and regulation for the environment and give incentives to encourage the investors to invest in clean energy project for clean environment.

Appendix

Table 10 List of countries

Australia	Ireland	Spain
Austria	Italy	Sweden
Belgium	Japan	Switzerland
Canada	Korea	Turkey
Czech Republic	Luxembourg	UK
Denmark	Mexico	USA
Finland	Netherlands	Chile
France	New Zealand	Estonia
Germany	Norway	Israel
Greece	Poland	Latvia
Hungary	Portugal	Lithuania
Iceland	Slovak Republic	Slovenia

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