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RESEARCH ARTICLE

# Dynamic linkages among $CO_2$ emissions, human development, financial development, and globalization: empirical evidence based on PMG long-run panel estimation

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**Abstract**

This study investigates the impact of the human capital index, globalization, and financial development on carbon dioxide of grouping OECD countries using pool mean group estimation technique from 1990 to 2015. This study also applies the second-generation cross-sectional augmented Dickey-Fuller and cross-sectional Im, Pesaran, Shin panel (CIPS) unit root, and the latest (Westerlund 2008) cointegration tests for further investigations. The result shows that both the human development index and financial development stimulate environmental improvement by using PMG long-run panel estimation approach. Furthermore, the pairwise Dumitrescu-Hurlin panel causality results prove the two-way causal association between financial development and carbon emissions. The unidirectional causality running from globalization and human development index towards carbon emission is also supported. Based on the aforementioned results, we provide a set of recommendations for policy implication.

**Keywords** Financial development · Globalization · Human development index · $CO_2$ emissions · OECD countries

## Introduction

Environmental degradation has drawn global concerns among academicians, ecological scientists, policymakers, governments, and all other concerning stake-holders since the Rio earth summit in 1992 followed by the recent Paris agreement on climate change in 2015. From the inception, the era of globalization, 2.7% increase of greenhouse gas (GHG) emissions per annum has been recorded 3 years after the release of the landmark Paris agreement (Le Quéré et al. 2018). Thereby, this increase in GHG emissions further shows the need for conscious actions to mitigate the consequences of climate change. Therefore, immediate steps are required to limit the disruption of climate caused by GHG emissions (Creutzig 2015). Among the greenhouse gases, $CO_2$ accounts for about 60% of harmful gases emitted in the atmosphere (Zhu et al. 2016), having the spillover effects of globalization as the main cause (You and Lv 2018).

In the last three decades, globalization has accelerated the revolution between the world's economies. It also links our nations politically, culturally, socially, and economically and thereby escalates economic growth through trade and foreign direct investment (Latif 2018). In the scenario of globalization, guest countries fixed their companies in host realms frequently compromising the ecological equilibrium (Akadiri et al. 2019; Shahbaz et al. 2016) ignoring the sustainability standards for environmental protection. Moreover, globalization contributes significantly to global warming and climate change which eventually threatens environmental and living conditions ( Le Quéré et al. 2018).

Globalization plays a crucial role in promoting manufacturing process and extensive use of fossil energy (Haseeb et al. 2018; Ahmed et al. 2019b) resulting in a hazardous impact on health and environment (Zafar et al. 2019). Thereby, the pros and cons of globalization cannot be neglected. In the case of OECD countries,

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business operations are mostly dependent on conventional sources of energy. According to a recent report on electricity information, OECD countries use nearly 57.8% of conventional sources, such as coal, crude oil, and gas for the production of energy (IEA 2019), which increases significantly $CO_2$ emission and environmental damage. Hence, it is mandatory for OECD countries to address environmental issues and curtail $CO_2$ emission without compromising economic development.

The linkages and impact of financial development on $CO_2$ emissions, as well as insights in different areas have been observed by some scholars. Haider Zaidi et al. (2019) investigated the linkages between globalization, financial development, and carbon emissions. The authors found out that globalization causes financial development and energy intensity and thus increase $CO_2$ emissions which are supported by other findings (Saud et al. 2019; Haseeb et al. 2018). Differently, other researchers found that financial development leads to the induction of green-energy technologies which mitigates $CO_2$ emissions (Saud et al. 2018a; Ganda 2019). Similarly, Ahmad et al. (2019) found that financial development attracts FDI, resulting in enhancing environment improvement. Ultimately, financial development and carbon dioxide emission have a mixed relationship.

In recent years, climate change along with its hazardous impacts has become a hot area of research. According to Wang et al. (2019b and Ahmed et al. (2019a), carbon emissions and its damaging effects on health condition cannot be denied. Human development index (HDI) is an indicator that plays a significant role in boosting up the political profile of general health and education-related policies (Shah 2016) and thereby indicates a country's vision in solving environment-related issues (Wang et al. 2018). Accordingly, the link between energy, sustainable development and economic development, HDI, and $CO_2$ emissions determines how close an economy is moving towards the sustainable development goals. According to Sinha and Sen (2016), HDI is considered as a measurement for the social and economic development of countries socially within the framework of UNDP.

Asongu (2018) found that $CO_2$ emission from the burning of fossil fuels is associated with human development depicting the ignorance of social extents of emission reduction. For example, the development strategy of China is to achieve the high growth in the domestic product by relying on low-efficient, low-cost technologies (Wang 2018a), which has contributed to dropping the poverty rate from 53% in 1981 to 8% in 2001. Although this type of development is not compatible with long-term climate targets, environmental policies cannot neglect the social implications of curbing $CO_2$ emission in a country, particularly during the early stages of human development. As commonly agreed, the intensity of the ecological challenges becomes apparent once the carbon emission per capita reaches the threshold of 2 tons (Sinha and Sen 2016) and human development index thresholds of 0.8 and 0.9, displaying the characteristics of a developed country. Under the current technological constraints, however, a rational distribution of $CO_2$ emissions should allow moving the developing countries towards the HDI thresholds 0.8 or 0.9, and at the same time, keep the global emissions below the limits in order to avoid anthropogenic climate change (Costa et al. 2011).

The correlation between financial, HDI, globalization, and carbon emission is inconclusive. The status of the connection of the variables mentioned above is ambiguous as it arises different sort of questions. Like at first level, there might be some necessary factors with different insights (affecting directly or indirectly) which are being neglected in relation between financial development, globalization, $CO_2$ emission, and HDI (Saud et al. 2018a; Maji et al. 2017; Shahbaz et al. 2017b; Shahbaz et al. 2019; You and Lv 2018; Sinha and Sen 2016). Many scholars have investigated the relation regarding globalization, environmental quality, financial development, and HDI, $CO_2$ emission, and there is a different school of thoughts for each variable with different insights. Various econometric techniques and tools for measurement have been applied in the past and current empirical studies.

Several empirical results provide evidence that globalization, in a likely manner to HDI and financial development, contributes largely to environmental damages in different regions of the world (Akadiri et al. 2019; Haseeb et al. 2018; Zafar et al. 2019). However, Hübner and Monnet (2014) found mixed results in the case of linkages between environmental degradation and globalization. Moreover, the findings by Shahbaz et al. (2017b) revealed that globalization has a positive environmental impact in the case of China. Given these divergent insights and findings regarding the relationship among the aforementioned variables, we estimate the need for further empirical investigations. Therefore, we empirically examine the relationships among globalization, financial development, human development index, energy consumption, and economic growth in OECD countries applying the panel estimation technique of robust to heterogeneity and cross-sectional dependence. We particularly examine the contribution of financial development, globalization, and human development index upon $CO_2$ emissions.

By addressing the causal linkage among the financial development, human development index, globalization, economic growth, $CO_2$ emission, and incorporate energy consumption in case of OECD panel, this research at hand adds up its contribution to the literature. Furthermore, the recommendations for policy implementation regarding financial development, globalization, human development index, and carbon dioxide emissions as stated in this study provide in-depth practical insights to policymakers and government politicians of OECD countries. Therefore, this study provides insights regarding the formulation of meaningful environmental policy that may help achieve sustainable economic development and long-run environmental performance. This study also uses the long-run estimation techniques called pool mean group, which is rarely used in the literature. Moreover, the use of the second-generation cross-sectional augmented Dickey-Fuller and cross-sectional Im, Pesaran, and Shin panel (CIPS) unit root tests also justify the contribution of this study. For measuring co-integration, Westerlund's (2008) analysis is used to overcome the problem of heterogeneity. Panel causality approach was employed (Dumitrescu and Hurlin) to investigate causal interaction among study variables.

The remaining sections of this study are sequenced as the following lines: in the section "Literature review with theoretical backgrounds", we massively explained the associated literature and previous empirical studies that focus on the influence of financial development, human development index, and globalization, on carbon emission. In section "Data source, econometric method", we explained the data source, variable measurement, and methodology. In section "Empirical results and Discussion", we tried to explain the results and discussions regarding study variables. In the section "Conclusion and policy suggestion", authors widely discussed the country-wise long-run analyses. In the last segment (6), conclusion and relevant policy recommendations are presented.

## Literature review with theoretical backgrounds

Literature review for our piece of research work provides numerous determinants of pollution, such as financial development, globalization, human development index, economic growth, and energy consumption. The pairwise correlation based on past empirical studies among the study variables has been mentioned in under given paragraphs.

### Globalization and $CO_2$ emissions

During the past decade, some scholars (e.g., Tiwari et al. 2013; Kanjilal and Ghosh 2013; Chang 2012; Shahbaz et al. 2012; Lee and Min 2014) have reported the impact of globalization on carbon emissions and environmental degradation. These findings are supported by the results of other studies for Saharan African states and developed countries, respectively (see Kwabena et al. 2017; Shahbaz et al. 2017a). By a stark constrast, Shahbaz et al. (2015) and Lee and Min (2014) found that globalization contributes to reduction of emission in the case of Mainland China and 255 countries, respectively. Consistent with these previous findings, several other studies found that globalization plays a vital role in mitigating carbon emission for African countries and Australia, respectively (Shahbaz et al. 2016; Shahbaz et al. 2015), which is supported by the past findings of Werner antweiler et al. (2001).

### Financial development and $CO_2$ emissions

Financial development mitigates financial risk and capital cost (Katircio et al. 2018) by directly affecting the economies of nations. Meanwhile, financial development may damage the environment as it increases the energy demands and $CO_2$ emission in different ways (Sadorsky 2010). Many scholars have investigated the nexus between financial development and carbon emission across the globe and thus found elusive and mixed the results (Islam et al. 2013; Boutabba 2014). In their empirical study, Abbasi and Riaz (2016) found that financial development increases $CO_2$ emissions rather than decreasing it. Similarly, financial development was observed to inflict disastrous effect on the environment (Shahbaz et al. 2016). According to Bekhet et al. (2017), financial development remains the primary source of high emit in the Gulf Cooperation Council countries except in the United Emirate Arabia. The bidirectional causal interaction among financial development and emissions was also observed in the studies by Kahouli (2017), Khan (2017), and Tariq et al. (2017) for different regions. Baloch (2018) found that financial development unpredictability does not increase carbon in the case of Saudi Arabia. However, the findings of Riti et al. (2017) showed that financial development is capable of decreasing $CO_2$ emission. In contrast to the aforementioned results, Salahuddin et al. (2017) concluded that the financial development does not cause emission in the case of Kuwait.

### Economic growth, energy, and $CO_2$ emission

Recently, global warming has become an urgent environmental issue for further observations that is mainly concerned with the emission of greenhouse gas, particularly $CO_2$ emissions (Rasool et al. 2019). Carbon emission is closely associated with energy consumption and economic growth (Liu and Hao 2018). The evidence of surging $CO_2$ emissions related to the consumption of energy and economic growth was identified by Kraft (2017). According to Kraft (2017), economic growth is attained through considerable utilization of energy, which results in increasing $CO_2$ emissions. In this regard, Stern (2004) argued that the viable development is hard to achieve without provision against global warming and climate change.

Studies by Shahbaz et al. (2012) in the context of Romania and (He and Reiner 2016) in context of China reported that the economic growth might mitigate the purity of the environment. The relevancy between the studies of Bedir and Merve (2016) and Wang et al. (2011) for correlation among carbon emit, economic growth, and energy utilization was observed. Scholars like Alam et al. (2012) studied the linkage between carbon dioxide emissions, conventional energy use, and economic growth in Bangladesh. The authors found a uni-directional causality running from energy consumption to economic growth both in the short and the long run. However, the result indicates a bi-directional long-run causality between electricity consumption and economic growth with no causal relationship in short run. Furthermore, Alam and colleagues found a uni-directional causality running from energy consumption to $CO_2$ emission in the short run while the feedback causality was depicted in the long run. Using the panel data, Dritsaki and Dritsaki (2014) analyzed the relationship among traditional energy use, economic growth, and $CO_2$ emission in Greece, Spain, and Portugal. Their results revealed that as energy usage increases, it also causes an increase in economic growth, which directly affects environmental sustainability.

### Human development and $CO_2$ emission

The HDI is a combination of different sort of indicators which includes life expectancy, education, and per capita income, respectively. A country scores higher human development index when the life, education, learning, and per capita rate is higher. Consequently, some studies confirmed that economic development is vigorously associated with human development, and also positively correlated with human capital (Ashraf et al. 2017; Dias and Mcdermott 2006; Pablo-romero and Sánchez-braza 2015). The statement may be supported by the fact that innovative, skilled, educated, and knowledgeable workforce is considered as an output element in the manufacturing process and accredited in the human capital framework. Given the significant importance of human capital, many developed countries have transformed themselves from a labor-based economy to the knowledge-based economy.

Sinha and Sen (2016) probed the causal link among the economic growth, trade, $CO_2$ emission, and human development indicators for BRIC countries from 1980 to 2013. They found that $CO_2$ emission increased global issues, which are a crucial indicator of human development. In the few BRIC countries, the authors also found that feedback hypothesis between $CO_2$ emissions and human development is supported, which is in synch with the result of a study by Zaman et al. (Zaman and Ahmad 2016). Pîrlogea (2012) argued that energy utilization and intensity indicators are utilized to confirm their impact on the human development index. This statement seems plausible for two reasons. First, energy is considered as an important resource for all economic activities. Second, the use of energy is the leading cause of greenhouse gas emission, which is harmful to both human health and the betterment of the environment. In conclusion, energy consumption and human development are directly correlated (IEA 2011; Wu et al. 2012).

To a great extent, both energy consumption and human development need to be taken into account when drafting climate policies and development strategy. In an empirical study, Pîrlogea (2012) found that $CO_2$ emissions decrease the value of human development in Romania, Bulgaria, and Poland. However, the author found that an increase of 1% $CO_2$ emission enhances the human development index by 0.192% in Portugal, Ireland, and Netherland. Noteworthy, Greenstone and Hanna (2014) argued that countries with high human development index have the absorptive capacity and resources to develop technology that helps them fight pollution. As a result, these countries have experienced relatively fewer health issues and feasible repercussions on environmental change (Table 1).

## Data source, econometric method

### Data and measurement

For the present study, a balance panel of OECD member countries has been selected, namely Australia, Austria, Canada, Chile, Denmark, Finland, France, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Mexico, Netherland, New Zealand, Norway, Portugal, Sweden, Spain, Switzerland, Turkey, United Kingdom, and United States by retrieving yearly data from 1990 to 2014. Herein, sample and countries were designated on the base of availability of their figures. We collected the figures of financial development (domestic and private sector % GDP), energy consumption (kg of oil equivalent per capita), gross domestic product (constant 2010 USD), and $CO_2$ (metric ton per capita), from WDI and globalization index from the KOF and human development data from human development index.

Long and healthy life = life expectancy at birth

Education = mean years of schooling and expected years.

A decent standard of living = gross national income per capita (PPP US$).

The following three indicators are formulated below.

### Estimation methodology (PMG)

In this study, we used the pooled mean group estimation approach developed by Pesaran et al. (1999) to investigate the correlation between variables. Under the pooled mean group technique, the long-term dynamics are based on the assumption of homogeneity, but short-run parameters are permitted to vary across the countries. Unlike the fully modified OLS and dynamic OLS, this technique highlights the error correction term, which displays the adjustment between long term and short term. Furthermore, the pooled mean group technique can be employed without investigating the unit root properties of the variables, and it is suitable even if variables pose a mixed order of integration (Ahmed and Wang 2019; Wang et al. 2019a). The short-run and long-run dynamics are estimated

**Table 1** Variables' name, symptoms, and reference of data collection

| Variables | Symptom | Unit | Definition |
|---|---|---|---|
| Carbon dioxide | $CO_2$ | Metric ton per capita | $CO_2$ emissions are the sum of burning fossil fuel, consumption of solid, liquid, gas fuel, and gas flare. |
| Energy consumption | *EC* | Kg of equivalent per capita | Energy consumption comprises the combustibles renewable, natural gas, petroleum merchandise, electricity, and waste. |
| Economic growth | *GDP* | Constant (2010 US $) | GDP = private consumption plus government expenditure plus (export minus import). |
| Human development | *HDI* | % | A human development index is a statistical tool used to calculating a country's overall progress in it's social and economic. |
| Financial development | *FD* | (% of GDP) | It is domestic credit to the private sector percentage of GDP |
| Globalization | *GI* | KOF Index from 0 to 100 | Globalization is the process of interaction among the people, companies, and government worldwide. |

Data of all the variables retrieve from these data source WDI 2017, HDI report 2018, and KOF Index of Globalization 2018.

simultaneously by employing an error correction model in the following Eq. (1).

$$CO_2 = f(GI + HDI + GDP + EC + FD) \quad (1)$$

We used natural logarithm for a sample distribution wherein some sample values are too large and some values are small in a different period. This circumstance gives rise to an outlier in the data.

$$lnCO_{2it} = \beta_0 + \beta_1 lnGi_{it} + \beta_2 lnHDI_{it} + B_3 lnEC_{it} + \beta_4 lnFD_{it} + \beta_5 lnGDP_{it} + \mu_{it} \quad (2)$$

where $i$ represents the number of cross-sectional (i.e., 1, 2, 3, 4… $N$) and $T$ indicates the period (1990–2015).

$Ln\mathrm{CO}_2it$ expresses carbon dioxide emission; $\beta_0$ represents the slope intercept; $\beta_1$, $\beta_2$, $B_3$, $\beta_4$, and $\beta_5$ coefficient estimated the globalization, human development index, energy consumption, financial development, and economic growth, respectively, while $\mu_{it}$ displays the error correction term.

In addition to the PMG estimator, we employed FMOLS of Pedroni (1996) and group mean dynamic ordinary least square proposed by Kao and Chiang (1997) to check the robustness of the results generated by pooled mean group method. The FMOLS technique overcomes the issues that arise from serial correlation and endogeneity in the OLS estimator. The DOLS estimator eliminates the serial correlation and potential endogeneity problem and generates reliable estimates.

## Cross-sectional dependence test

Before calculating the unit root properties of the variables of this study, we detected the existence of cross-sectional dependence in the data series. Cross-sectional dependence can be detected in the panel data due to common shocks, unobserved mutual factors, and spillover effect. In the case of cross-sectional dependence, traditional unit root and cointegration test may produce biased results. Different tests can be used to measure the cross-sectional dependence. For instance, the cross-sectional dependence (CD) test is useful in case of large N and small T in the panel data (Pesaran 2004). In contrast, LM test can be applied for panel data with large T and small N. Herein, we used Breusch, Pagan LM test, Pesaran CD test, and Pesaran scaled LM test for reliable results (Breusch and Pagan 1980). The result provides reinforcing proof to discard the null hypothesis of cross-sectional dependence as the relevant $p$ value is below 0.01. Thus, findings display the existence of cross-sectional relationship for human development index, energy consumption, economic growth, $CO_2$ emission, globalization, and financial development. Cross-sectional dependence is followed as equation.

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i-1}^{N-1}\sum_{J=I+1}^{N} pij\right) \quad (3)$$

## Unit root test CIPS and CADF

At the start of empirical analyses, the panel unit root test was used to determine the cross-sectional dependence and the pattern of integration of the variables, as defined in the selection of an econometric model for the analyses. We used cross-sectional augmented Dickey-Fuller and cross-sectional Im, Pesaran, and Shin panel unit root test developed by Pesaran (2004, 2007). CIPS and CADF tests work under the postulation of the cross-sectional dependence. The null of a unit root is tested against the alternative hypothesis. If all variables are significant in the order of one or first level, then this shows that all variables are non-stationary at the level and stationary at the first level. This outcome proposes that these variables have a significant cointegration relationship in the long run.

### Panel cointegration test

The panel co-integration approaches were used to analyze the long-term equilibrium among the variables. For this purpose, we used Durbin-Hausman method, which was proposed by Westerlund (2008) to determine the existence of co-integration. This test does not require knowledge about the order of integration among the variables, and it also accounts for cross-sectional dependence and heterogeneity. $\varepsilon_{it}$ are attained via the idiosyncratic invention and unobservable factors that are common across units of the panel. Thus, residuals are modeled as follows.

$$\begin{aligned} Zit &= \lambda \mathrm{iFt} + \varepsilon it \\ Fjt &= \rho j + Fj(t-1) + \upsilon jt \\ \varepsilon it &= \varphi + \varepsilon i(t-1) + \eta it \end{aligned} \quad (4)$$

where $\boldsymbol{Ft}$is the k-dimension vector of common factors $Fjt$with $j = 1\ldots\ k$ and $\lambda i$ is the conformable vector of factor loading. By assuming that $\rho j< 1$ for all $j$, we ensured that $\boldsymbol{Ft}$is stationary. In this situation, the integration order of the composite regression residual $Zit$relies only on the integration of the idiosyncratic disturbance$\varepsilon it$. Therefore, testing the null of no cointegration is equal to testing whether $\varphi i = 1$. Two-panel cointegration test can perform the first-panel analysis and second-group mean test. The first test is constructed under the maintained assumption that is$\varphi$, $\varphi i = \varphi$for all $i$, while the second is not. Both tests are composed of two approaches of$\varphi i$, which have various possibility parameters under the co-integration alternative hypothesis but share the characteristic of consistency under the null hypothesis of no cointegration. The instrumental variable estimators (IV) and OLS estimators can be employed to obtain the Durbin-Hausman tests. Thus, the statistics of $DH_g$ and $DH_p$ tests are expressed as

$$\begin{aligned} DH_g &= \sum_{i=1}^{N} \hat{S}_i (\varphi_{1i} - \varphi_{2i})^2 \sum_{t=2}^{T} \hat{e}_i^2 (t-1) \\ DH_p &= \hat{S}_n (\varphi_1 - \varphi_2)^2 \sum_{i=1}^{N} \sum_{t=2}^{T} \hat{e}_{i(t-1)}^2 \end{aligned} \quad (5)$$

where$\varphi 2i$ denotes the OLS estimator of $\varphi i$ in Eq. (5) and $\varphi 2$represents its pooled counterpart. The corresponding and pooled instrumental variable estimators of$\varphi i$ express $\varphi 1i$ and$\varphi 1$, in that order, are obtained via simply instrumenting $\hat{e}\ i(t-1)$ with$\hat{e}it$. For the panel test $DH_p$, the null hypotheses and alternative hypotheses are expressed as H0: $\varphi i =$ for all $i = 1\ldots N$ versus $H_{1p}$:$\varphi i = \varphi$and$\varphi < 1$ for all $i$. Hence, in this situation, we are in effect, presuming a common value for the autoregressive parameter both under the null hypotheses and alternative. In the other side, the mean group ($DH_g$) test, $H_0$, is tested against the alternative hypothesis defined as $H^1{}_g = \varphi i < 1$ for at least some $i$. In this situation, the heterogeneous autoregressive parameter is presumed to be an across-sectional member. Therefore, the rejection of the null hypothesis denotes that there is a long-run link between some of the panel units.

Average annual growth rate

Table 2 highlights the average annual growth rates for the selected variables in 25 OECD countries spanning from 1990 to 2015. All selected countries display either a positive or a negative $CO_2$ emission growth figure. Table 6 shows that Chili (3.99%), Turkey (3.56%), Mexico (2.413%), and Korea (2.011%) have the highest $CO_2$ emission growth, whereas United Kingdom (1.065%), Portugal (0.755%), Norway (0.673%), Israel (0.125%), and Spain (0.052%) have the lowest $CO_2$ emission growth. However, many countries have a negative $CO_2$ emission growth: Switzerland (− 1.830%), Canada (− 1.175%), United States (− 0.754%), and Sweden (− 0.642%) to name a few. The top five (5) globalization highest growth rate countries are Korea (1.794%), Mexico (1.509%), Chili (1.427%), Greece (1.259%), and Turkey (1.189%) (see Table 6). The top five (5) countries with the highest economic growth rate are Ireland (4.132%), Korea (4.288%), Chili (3.630%), Turkey (2.906%), and Israel (1.887%), as indicated in Table 6. The highest growth rate of energy consumption is recorded in Korea (3.677%), Iceland (2.840%), and Turkey (2.139%), while United Kingdom (− 0.964%), United States (− 0.447%), and Switzerland (− 0.737%) are among the countries that have experienced a negative growth rate of energy consumption.

All the sample countries have achieved significant growth rate of HDI. However, Turkey (1.109%), Korea (0.809%), Ireland (0.743%), Chili (0.737%), and United Kingdom (0.621%) are the top five countries with the highest HDI growth rate, whereas United States (0.259%), Canada (0.309%), Austria (0.454%), and Australia (0.312%) are the top four (4) with lowest human development growth rate (see Table 6). Finally, Table 6 shows that most of the countries in the sample have registered significant financial development growth rate from 1990 to 2015. With this respect, the top five (5) are Denmark (10.744%), Turkey (6.438%), Sweden (5.397%), Greece (5.377%), and Iceland (4.548%). However, Japan (− 0.055%) and Austria (− 0.055%) have registered a negative financial development growth rate. These findings indicate that the sample countries have been growing well in terms of the human development index, economic growth, globalization, and human development index.

Dumitrescu-Hurlin causality tests

Along with the short-term and long-term estimation results, it is vital to know the direction of a causal association between the variables considered in this study. In this regards, the present study relies on the pairwise Dumitrescu-Hurlin panel causality tests, proposed by (Dumitrescu and Hurlin 2012). The DH is a cutting-edge method of the panel Granger causality. The results drawn from the causal relationships among the variables of interest will assist policymakers in establishing and implementing appropriate policy in the future.

**Table 2** Compound annual growth rate and summary of descriptive statistics

| Country | $CO_2$ | GI | GDPPC | EC | HDI | FD |
|---|---|---|---|---|---|---|
| Australia | − 0.6384 | 0.637168 | 0.018661 | 0.335865 | 0.311934 | 3.220653 |
| Austria | 1.396558 | 0.580825 | 1.342479 | 0.671281 | 0.453993 | − 0.05511 |
| Canada | − 1.17527 | 0.513832 | 1.245442 | 0.018793 | 0.309662 | 0.925208 |
| Chili | 3.999385 | 1.427583 | 3.630052 | 2.625413 | 0.737029 | 3.785828 |
| Denmark | − 0.4375 | 0.41141 | 1.1682 | − 0.55801 | 0.565864 | 10.74395 |
| Finland | − 0.53529 | 0.724422 | 1.221254 | 0.266529 | 0.51647 | 0.695056 |
| France | − 0.45493 | 0.627648 | 0.960301 | − 0.10488 | 0.544809 | 0.184918 |
| Greece | − 0.21036 | 1.259039 | 0.658571 | 0.202001 | 0.504742 | 5.377005 |
| Iceland | − 0.25944 | 0.858415 | 1.534518 | 2.840326 | 0.558407 | 4.548587 |
| Ireland | − 0.56695 | 0.549512 | 4.132495 | 0.074439 | 0.743381 | 1.982426 |
| Israel | 0.125343 | 1.007739 | 1.887342 | 0.585954 | 0.52342 | 1.09651 |
| Italy | − 0.33285 | 0.624908 | 0.385973 | − 0.10115 | 0.55601 | 2.029335 |
| Japan | − 0.18444 | 1.097182 | 0.853699 | − 0.09595 | 0.400107 | − 0.08169 |
| Korea | 2.011399 | 1.79365 | 4.28865 | 3.67794 | 0.809074 | 4.284745 |
| Mexico | 2.413136 | 1.509412 | 1.127256 | 0.136528 | 0.625623 | 3.752365 |
| Netherland | − 0.57729 | 0.53952 | 1.442071 | − 0.0906 | 0.415225 | 1.674697 |
| New Zealand | 0.348519 | 0.612212 | 1.419671 | 0.577904 | 0.432379 | 1.192611 |
| Norway | 0.673628 | 0.412932 | 1.552212 | 0.839703 | 0.43002 | 3.626669 |
| Portugal | 0.755797 | 1.038638 | 1.086891 | 0.994142 | 0.658335 | 4.067307 |
| Sweden | − 0.64174 | 0.459615 | 1.528324 | − 0.21504 | 0.438771 | 5.397555 |
| Spain | 0.052299 | 0.964545 | 1.202229 | 0.469955 | 0.609104 | 1.944717 |
| Switzerland | − 1.83009 | 0.535854 | 0.661993 | − 0.73707 | 0.471746 | 0.602598 |
| Turkey | 3.567035 | 1.189372 | 2.906606 | 2.139534 | 1.109413 | 6.438936 |
| United Kingdom | 1.065296 | 0.467872 | 1.425103 | − 0.96391 | 0.621081 | 1.093393 |
| United States | − 0.75446 | 0.466932 | 1.382508 | − 0.44711 | 0.259855 | 2.063642 |
| Consolidate | | | | | | |
| Mean | 8.610215 | 77.06775 | 36702.23 | 4253.680 | 0.844080 | 98.56075 |
| Maximum | 20.17875 | 90.23753 | 91594.18 | 18178.14 | 0.949000 | 312.1179 |
| Minimum | 2.327632 | 47.99652 | 5947.765 | 947.7563 | 0.576000 | 13.44640 |
| Std. Dev. | 3.864789 | 9.010086 | 17543.66 | 2498.563 | 0.066907 | 48.25369 |

For growth rate measurement, we have used original panel data

Description of the variables; $CO_2$ (per capita carbon dioxide in matric tone), GI (globalization), GDP (gross domestic product per capita constant 2010 US$), EC (energy use kg of oil equivalent per capita), HDI (human development index), FI (financial development domestic credit to private sector % of GDP)

The results drawn from the DHP causality test are described in Table 3. From results, we infer the existence of a bidirectional causal association between financial development and environmental quality. This result matches with many prior empirical studies (Al-Mulali and Ozturk 2015). The two-way causal association is detected between energy use and environmental degradation. The results also show a bidirectional causal relationship between energy consumption and environmental degradation. This suggests the adoption of advanced and energy-efficient technology to reduce high energy consumption and mitigate the emission of greenhouse gases. This result is corroborated by previous empirical studies (see, for example, Farhani and Ozturk 2015; Shahbaz et al. 2013c). For GDP and financial development, Table 3 depicts a bidirectional causal relationship, which is also supported by several other empirical studies (Al-mulali and Lee 2013; Islam et al. 2013).

Additionally, globalization and financial development have a two-way causal relationship. This result is partially supported in an empirical study by Saud et al. (2018b). For the human development index and GDP, we found a bidirectional causal association. However, we found a unilateral causal connection running from GDP towards environmental quality. This finding is supported by the studies (Shahbaz 2013; Shahbaz et al. 2017b) and partly corroborated by the outcome of the study of Shahbaz et al. (2013c) and Katircioglu (2017). Furthermore, a unidirectional causal link is found between globalization and mitigation of environmental carbon dioxide emission, whereas a one-way causal link is found between the HDI and ecological degradation.

Moreover, the result of this study shows unidirectional causal association running from human development index to financial development and from GDP to energy consumption, which is supported by prior empirical studies (Toman and Jemelkova 2003; Aziz 2011). As shown in Table 3, there exists a one-sided causal link running from globalization towards energy consumption. Similar results were also found in several other studies (Shahbaz et al. 2013c; Saud et al. 2018b). Also, the one-way causal association is detected from human development index to energy consumption and economic growth (see Table 3). This result supports the view of Shahbaz et al. (2013c). Finally, a one-way causality running from globalization towards human development index is found in Table 3.

## Empirical results and discussion

In this paper, we investigated the effect of globalization, financial development, and human development index on $CO_2$ emission along with the impact of economic growth and energy consumption on $CO_2$ emission using panel data of 25 OECD countries. The test and the findings are discussed as follows:

### Results of cross-sectional dependence and unit root test

Before finding the results of the unit root test, it is essential to analyze the cross-sectional dependence in the variables. Based on cross-sectional dependence, we can apply the unit root test. Without cross-sectional dependence, unit root tests show an inappropriate mechanism. Therefore, we examined whether the variables considered in this study have cross-sectional dependence or not? We used the Pesaran (2004), Breusch-Pagan LM test for determination of cross-sectional dependence of the variables. The outcomes demonstrate that the null hypothesis of cross-sectional independence is firmly rejected at 1% significance (see Table 4). Based on the cross-sectional dependence analyses results, we employed the Pesaran (2007) unit root test CIPS and CADF, accounting for the cross-sectional dependence. The CIPS and CADF test outcomes are mentioned in Table 5. The results confirm that the null hypothesis is accepted for all variables. But when we applied this test at first difference, then the null hypothesis is firmly rejected for all variables at a 1% level of significance. This finding confirms a similar order of integrated indication for variables, i.e., I (1), which suggests that there might have a co-integration association between the variables in the long run.

### Results regarding panel cointegration test analyses

As the panel unit root test confirmed that all variables are associated in a similar pattern, therefore, the existence of co-integration for all variables is justified. The outcomes of DHg and DHp tests are presented in Table 6. The results of DHg and DHp tests reveal that the null hypothesis of no-cointegration is unacceptable at 1% level of significance, indicating long-run importance among the nexus of variables for the panel of OECD.

### Panel estimate of long-run analyses

The afore-mentioned panel unit analyses affirmed that all variables of this study are integrated at the same order. Therefore, we applied FMOLS and DOLS test for finding the long-run equilibrium linkages among the variables. The results of FMOLS and DOLS are described in Table 7. Our results demonstrate a significant long-run equilibrium association among study variables.

### The long-run cointegration analyses

The above analysis only confirmed the long-run relationship but did not magnify the positive or negative strength of association among the variables over a specific time of period. Hence, we used the pool mean group method for long-run analyses. All variables were converted into the logarithms to ensure that the long-term coefficient examined for FD, GDP, GI, EC, and HDI are econometrically equivalent to the elasticities of $CO_2$ emission, economic growth, financial development, human development index, energy consumption, and globalization, respectively. The outcomes showing the long-term dynamic are presented in Table 7.

The dynamic analysis confirms that globalization increases the amount of $CO_2$ emission in OECD countries. For example, a 5% increase in the rate of globalization leads to 0.498% increase in $CO_2$ emission. That might result as a consequence when a country opens its boundaries for openness and investment activities; therefore, trade openness and financial development stemming from globalization might have an upward effect on FDI in OECD economy. Thereby, an increase in FDI flow is likely to lead to higher energy consumption, which eventually increases the level of $CO_2$ emission. This also happens when international investors come to the host country and install their industries using the conventional methods for the initial production and use old technology to reduce their preliminary cost. In fact, conventional resources generally consume a higher amount of energy, which eventually emits more $CO_2$ in comparison to high-end technology and resources. Additionally, corporate firms hesitate to follow similar environmental protection regulations when operating in host countries in contrast to their own country. This often

**Table 3** Pairwise panel causality test

| Null hypothesis | W-Stat | Zbar-Stat | Prob |
|---|---|---|---|
| LOGFD does not homogeneously cause LOG$CO_2$ | 5.86188 | 7.20778 | 6.E-13 |
| LOG$CO_2$ does not homogeneously cause LOGFD | 3.66080 | 2.83318 | 0.0046 |
| LOGIC does not homogeneously cause LOG$CO_2$ | 3.92765 | 3.36353 | 0.0008 |
| LOG$CO_2$ does not homogeneously cause LOGEC | 3.19549 | 1.90839 | 0.0563 |
| LOGGDP does not homogeneously cause LOG$CO_2$ | 7.28709 | 10.0404 | 0.0000 |
| LOG$CO_2$ does not homogeneously cause LOGGDP | 1.73600 | − 0.99235 | 0.3210 |
| LOGGI does not homogeneously cause LOG$CO_2$ | 3.89356 | 3.29578 | 0.0010 |
| LOG$CO_2$ does not homogeneously cause LOGGI | 1.68550 | − 1.09271 | 0.2745 |
| LOGHDI does not homogeneously cause LOG$CO_2$ | 6.06250 | 7.60651 | 3.E-14 |
| LOG$CO_2$ does not homogeneously cause LOGHDI | 1.87984 | − 0.70646 | 0.4799 |
| LOGEC does not homogeneously cause LOGFD | 4.93389 | 5.36342 | 8.E-08 |
| LOGFD does not homogeneously cause LOGEC | 6.98249 | 9.43498 | 0.0000 |
| LOGGDP does not homogeneously cause LOGFD | 6.75921 | 8.99123 | 0.0000 |
| LOGFD does not homogeneously cause LOGGDP | 4.99297 | 5.48085 | 4.E-08 |
| LOGGI does not homogeneously cause LOGFD | 5.98208 | 7.44668 | 1.E-13 |
| LOGFD does not homogeneously cause LOGGI | 2.73474 | 0.99265 | 0.3209 |
| LOGHDI does not homogeneously cause LOGFD | 5.44034 | 6.36999 | 2.E-10 |
| LOGFD does not homogeneously cause LOGHDI | 2.49262 | 0.51142 | 0.6091 |
| LOGGDP does not homogeneously cause LOGEC | 5.51680 | 6.52195 | 7.E-11 |
| LOGEC does not homogeneously cause LOGGDP | 1.83680 | − 0.79200 | 0.4284 |
| LOGGI does not homogeneously cause LOGEC | 3.52480 | 2.56287 | 0.0104 |
| LOGEC does not homogeneously cause LOGGI | 1.81873 | − 0.82791 | 0.4077 |
| LOGHDI does not homogeneously cause LOGEC | 4.08076 | 3.66785 | 0.0002 |
| LOGEC does not homogeneously cause LOGHDI | 1.73577 | − 0.99280 | 0.3208 |
| LOGGI does not homogeneously cause LOGGDP | 3.95927 | 3.42638 | 0.0006 |
| LOGGDP does not homogeneously cause LOGGI | 2.41854 | 0.36420 | 0.7157 |
| LOGHDI does not homogeneously cause LOGGDP | 5.20418 | 5.90063 | 4.E-09 |
| LOGGDP does not homogeneously cause LOGHDI | 3.20449 | 1.92626 | 0.0541 |
| LOGHDI does not homogeneously cause LOGGI | 2.89624 | 1.31362 | 0.1890 |
| LOGGI does not homogeneously cause LOGHDI | 3.10742 | 1.73334 | 0.0830 |

happens in the context of weak institutional environments where government institutions are not capable of implementing and ensuring compliance towards environmental regulations (Mombeuil and Fotiadis 2019). Our result endorses the findings of Shahbaz et al. (2017a), Xu and Baloch (2018), Haseeb et al. (2019) for developed countries, Saudi Arabia and BRICS countries, respectively, but inconsistent with a finding of Shahbaz et al. (2015) for India.

**Table 4** Result of cross-sectional dependence

| Variables | Pesaran CD | Pesaran scaled LM | Breusch-Pagan LM |
|---|---|---|---|
| Log$CO_2$ | 30.99500 (000) | 108.1965 (000) | 2950.263 (000) |
| LogFD | 6.442307 (000) | 76.62496 (000) | 2176.921 (000) |
| LogGDP | 46.98109 (000) | 144.1278 (000) | 3830.396 (000) |
| LogEC | 25.94582 (000) | 100.2985 (000) | 2756.801 (000) |
| LogHDI | 47.74553 (000) | 117.7524 (000) | 3184.333 (000) |
| LogGI | 32.84867 (000) | 100.3104 (000) | 2757.093 (000) |

[a] The standard of rejection at 1%

The coefficient analysis of financial development indicates that a 1% rise in financial development mitigates the $CO_2$ emission by 0.0813. The findings of our study showed that financial development is the main factor for $CO_2$ emission reduction. Thus, financial development helps to develop or acquire advanced energy and efficiency effective technology, which, in

**Table 5** Result of CADF and CIPS panel unit root test

| CIPS | | CADF | | |
|---|---|---|---|---|
| Variables | At level | First difference | At level | First difference |
| Log$CO_2$ | − 1.684 | − 4.259[a] | − 1.520 | − 3.368[a] |
| LogGDP | − 1.706 | − 3.520[a] | − 1.971 | − 3.018[a] |
| LogEC | − 1.654 | − 5.054[a] | − 1.690 | − 3.849[a] |
| LogFD | − 1.467 | − 3.763[a] | − 2.270 | − 2.732[a] |
| LogHDI | − 2.029 | − 4.305[a] | − 2.637 | − 3.113[a] |
| LogGI | − 2.912 | − 4.924[a] | − 1.894 | − 3.990[a] |

Note: a, b, and c denote the statistical significance at 1%, 5%, and 10% level, respectively. The critical values can be provided upon request

**Table 6** Westerlund's (2008) cointegration tests

| | |
|---|---|
| $Dh_g$ | 4.992*** (0.000) |
| $Dh_p$ | 3.870*** (0.001) |

*P* values are mentioned in the bracket

The rejection of no co-integration null hypothesis at the level of 1% significant

turn, helps to reduce the $CO_2$ emission. Similarly, financial development brings the FDI, which supports research and development programs that introduces environmentally friendly technology and improves environment standard.

Financial development has other important implications. For example, it helps to finance the acquisitions, including installation of efficient technology; provides fund for exploration of renewable energy resources, promotes and allocates more resources to environmentally friendly technology in different countries (Shahbaz et al. 2013a; Shahbaz et al. 2013b; Dasgupta et al. 2006; Tamazian et al. 2009; Jalil and Feridun 2012; Khan and Ullah 2019; Saidi and Mbarek 2017).

Our dynamic analysis displays the connection between economic growth and the environment in the OECD nation-states. Economic growth and $CO_2$ emission are positively correlated with significant influence in the OECD countries. For example, a 1% increase in economic growth causes the 0.176% increase in $CO_2$ emission stemming from the use of fossil fuel as the primary source of energy production in OECD countries. Due to this, economic growth increases energy consumption, which results in the rise of $CO_2$ emission, which eventually harms the environment. For OECD member countries, an increase in the GDP turns into increasing energy consumption and carbon emissions.

OECD member countries are emerging economies which are actively participating in the global trade and contributing to the world's growth, which ultimately increase the level of $CO_2$ emission. Moreover, an extension in economic activities such as investment, purchases, and consumption is likely to raise the level of emission in the air. Another plausible reason behind the increase of $CO_2$ in OECD countries may be related to the use of non-energy efficient technology in the manufacturing process.

In OECD countries, energy consumption and $CO_2$ emission display positive effect. For instance, a 1% increase in energy consumption increases $CO_2$ emission by 0.747% $CO_2$ emission. It is generally agreed that energy performs a crucial role in economic activities. Consequently, the development and use of consumer technology increase the demand for energy consumption per capita and industrialization and economic growth processes. It is generally believed that countries with a high level of energy consumption are likely to have a high living standard, resulting in a higher level of energy consumption tending to augment $CO_2$ emission, which eventually damages the environment.

Our result unveils that human development and $CO_2$ emission have a negative and significant influence in OECD countries. The result thus shows that a 10% increase in human development index leads to 0.476% increase in $CO_2$ emission in the atmosphere. This study suggests that human development may significantly mitigate environmental issues and may also play a significant role in achieving sustainable growth in the region. It is agreed that human development helps to educate people on how to protect the environment and further increases the economic activities of a given country. Therefore, sustainable human development might be illustrated as a continuous rise in the social economics and living standards, which may be accomplished via an enhancement in stocks of physical and human capital and improvement in the technology and the environment. Additionally, by enhancing the level of HDI, it is more likely to increase people's awareness to meet the environmental sustainability goal of a country. On the other hand, higher HDI should ideally be graded higher in terms of environmental performance. Usually, a higher level of income is conducive to higher human development index, which in turn helps to maintain or increase the betterment of the environment. Our result is consistent with those found by Bano et al. (2018).

## Country wise long-run analysis

The long-run panel data analysis is already deliberated in the preceding part of this article. However, understanding the dynamic influence of human development and $CO_2$ emission in

**Table 7** Result for long-run analyses

| | PMG | | FMOLS | | DOLS | |
|---|---|---|---|---|---|---|
| Variable | Coefficient | T-statistic | Coefficient | T-statistic | Coefficient | T-statistic |
| Lfd | − 0.081340$^{(0.0000)}$ | − 4.734998 | − 0.077431$^{(0.0002)}$ | − 3.735885 | − 0.060807$^{(0.0311)}$ | − 2.174457 |
| Lec | 0.747876$^{(0.0000)}$ | 10.86677 | 0.608819$^{(0.0000)}$ | 10.29996 | 0.493565$^{(0.0000)}$ | 5.678130 |
| Lgdp | 0.176539$^{(0.0227)}$ | 2.289180 | 0.251602$^{(0.0038)}$ | 2.903194 | 0.537452$^{(0.0014)}$ | 3.241104 |
| Lgi | 0.498672$^{(0.0032)}$ | 2.970662 | 0.633984$^{(0.0002)}$ | 3.711210 | 0.490224$^{(0.0710)}$ | − 5.228736 |
| Lhdi | − 0.476749$^{(0.0703)}$ | − 1.815361 | − 1.532243$^{(0.0000)}$ | 3.711210 | − 2.558780$^{(0.0000)}$ | 1.816642 |

Note: Values in parentheses show *p* values each country is noteworthy. So, we further investigate the long-run analyses of $CO_2$ emission for time series data of each country. The (DOLS) technique is used for long-term analyses. The result of the DOLS is presented in Table 8. The outcomes of the investigations indicate that HDI regarding $CO_2$ emission is negative in Australia, Austria, Canada, Denmark, Finland, Iceland, Ireland, Israel, Italy, Japan, New Zealand, Turkey, and the United Kingdom. This discloses that human development negatively influences the $CO_2$ emission in these countries. To some extent, the aforementioned findings prove that human development performs a crucial role in overcoming the $CO_2$ emission in the environment. Therefore, we suggest that these countries should continue their policies, especially which are devised for improving the HDI.

In contrary, the results also indicate that the human development has a stimulating effect on the $CO_2$ emission in counties, such as Chili, France, Korea, Mexico, Norway, and United States. So, these countries should focus on human development because it is an essential factor for controlling $CO_2$ emission. These countries should, therefore, pour more investment in human development projects and educate their citizens to make good use of the available resources to improve the quality of the environment. Additionally, the policymakers should revamp their policy for better control over $CO_2$ emission. Likewise, the long-term elasticities of $CO_2$ emission related to globalization have positive and significant impact in Australia, Denmark, New Zealand, Sweden, and the United Kingdom. The above result shows that globalization increases the demand for energy, which in turn increases the $CO_2$ emission. It might be due to that the technology transfer by trade openness and foreign direct investment is not efficient and energy saving in the abovementioned countries (Wang et al. 2018b) , which makes the globalization to enhance the $CO_2$ emission in these countries. Due to this reason, we urge that governments have higher taxes for those technologies that discharge the $CO_2$ and deteriorate the quality of the environment.

Conversely, globalization displayed the negative effect on $CO_2$ emission in Austria, Canada, Mexico, Iceland, Netherland, Portugal, Spain, Switzerland, Turkey, and the United States. So, it is recommended that these countries essentially adopt energy-saving technology that helps mitigate $CO_2$ emission. In this case, the financial sector can play a crucial role by supporting R&D aiming at developing cleaner and renewable energy. In contrast to the above finding, financial development shows negative influence on $CO_2$ emission in Australia, Canada, Chile, Denmark, Finland, France, Iceland, Ireland, Italy, Japan, Korea, Mexico, New Zealand, Portugal, and Turkey. Thus, lower $CO_2$ emission witnessed in afore listed countries is due to $CO_2$ emission conservation policies.

## Conclusion and policy suggestion

The piece of work is framed to examine the influence of $CO_2$ emission and human development through incorporating financial development, economic growth, globalization, and energy consumption in OECD countries over the period from 1990 to 2014. We employed the PMG technique to estimate the long-run relationship. DHP causality test was used to seek a causal link among the study variables. Additionally, we used the cross-sectional method for finding the cross-sectional dependency among the variables and for the data stationary. We employed CIPS and CADF test and the Westerlund's (2008) used for examining the long-run equilibrium. Additionally, we also used DOLS and FOMLS methods for single country analysis.

The empirical results of our work suggested that the human development index contributes well to decrease the $CO_2$ emission in OECD countries in the long run. Findings of this study also reported that economic globalization considerably surges carbon dioxide emission in the long term. Also, energy consumption and economic growth were discovered as major culprits for a high amount of $CO_2$ emission in OECD countries. Taken together, the findings of our study further suggest that financial development does not play any role to enhance the $CO_2$ emission in case of OECD countries. In the end, the result of DH proved a bilateral causal association between financial development and the environment. But globalization and human development have a unidirectional relationship with $CO_2$ emission.

The empirical finding also suggested that globalization upward carbon emissions in OECD countries; hence, government and policymakers in these countries should introduce new policies related to globalization. First, they should restrict export opportunities for $CO_2$ intensive merchandise and services. Second, they may also require replaceable of that goods and services through the association of domestic sector to reduce the $CO_2$ intensity. Finally, an adaptation of border carbon taxes concerning the globalization and $CO_2$ emission price as a policy tool.

The present results reveal that financial development reduced the $CO_2$ emission in OECD countries. Financial development performs a crucial role in the mitigation of $CO_2$ emissions via financially supporting the companies to acquire environmentally friendly technologies during the manufacturing process. Financial development facilitates the flow of FDI from developing to emerging economies (Abbasi and Riaz 2016). Furthermore, financial development encourages the local businessmen and industrialist to adopt modern energy-efficient technology for production and operations. Furthermore, financial development can significantly contribute to combat the environmental degradation factors as it makes greater financial sources available within the country to work on different environment protection projects by taking the loan from country's own commercial banks. The

**Table 8** Country-wise long-run analyses

| Country | variables | Ln FD | Ln EC | Ln GDP | Ln GI | Ln HDI |
|---|---|---|---|---|---|---|
| Australia | Coefficient | − 0.148619 | 1.504053[a] | 0.467776[c] | 0.493549[c] | − 2.892412[b] |
| | *t* value | − 1.205881 | 24.65551 | 3.359124 | 3.578752 | − 4.073548 |
| Austria | Coefficient | 0.003782 | 1.830499[b] | − 0.349274 | − 0.233509 | − 2.328455[b] |
| | *t* value | 0.021491 | 5.216666 | − 1.360657 | − 0.780383 | − 5.444878 |
| Canada | Coefficient | − 0.061146 | 9.720499[b] | − 1.607822[b] | − 16.30501[b] | − 60.31606[b] |
| | *t* value | − 4.622142 | 25.91430 | − 36.70832 | − 23.98470 | − 28.86691 |
| Chili | Coefficient | − 0.906897[b] | 1.584695[c] | − 0.529474 | − 0.062061 | 5.076083[b] |
| | *t* value | − 3.210958 | 2.804383 | − 1.203821 | − 0.250840 | 5.561755 |
| Denmark | Coefficient | − 0.104917[a] | 1.213260[a] | 0.799674 | 3.531793[b] | − 3.801562[b] |
| | *t* value | − 10.89912 | 19.73525 | 1.923733 | 4.752810 | − 7.688963 |
| Finland | Coefficient | − 0.599511 | 1.557692 | 2.524019 | − 8.606243 | − 0.430340 |
| | *t* value | − 0.689126 | 0.584435 | 0.684174 | − 0.557791 | − 0.059667 |
| France | Coefficient | − 0.277158[a] | 1.983133[a] | − 1.368395[b] | 0.316470 | 3.264300[b] |
| | *t* value | − 12.92440 | 12.14082 | − 5.652548 | 0.566623 | 5.338978 |
| Greece | Coefficient | 0.242958 | 1.413586[b] | 0.052625 | − 0.868456 | − 2.990460 |
| | *t* value | 1.413617 | 7.714916 | 0.265958 | − 2.375438 | − 1.842688 |
| Iceland | Coefficient | − 0.307067[b] | 0.742041[c] | 3.792434[b] | − 0.074944 | − 6.664630[c] |
| | *t* value | − 3.964057 | 3.119639 | 6.313838 | − 0.146208 | − 3.052407 |
| Ireland | Coefficient | − 0.004815 | 0.785777[a] | 1.065578[b] | 0.080045 | − 5.416277[b] |
| | *t* value | − 0.404247 | 12.45474 | 7.907976 | 0.498591 | − 8.616293 |
| Israel | Coefficient | 0.589007[b] | 1.464546[a] | 0.020091 | 0.031689 | − 2.367336[c] |
| | *t* value | 6.572915 | 14.37210 | 0.162791 | 0.160316 | − 3.114158 |
| Italy | Coefficient | − 0.017475 | 1.779090b | − 0.313312 | 0.059251 | − 1.748069 |
| | *t* value | − 0.202969 | 5.482576 | − 0.686687 | 0.113654 | − 2.723691 |
| Japan | Coefficient | − 0.030303 | 0.173875 | − 0.480967 | 1.030703 | − 1.278872 |
| | *t* value | − 0.218166 | 1.259492 | − 1.092441 | 2.314851 | − 1.045510 |
| Korea | Coefficient | − 0.120373 | 1.046438 | − 0.424946 | − 0.311528 | 2.637402b |
| | *t* value | − 0.746662 | 1.297330 | − 1.026354 | − 0.325069 | 5.553881 |
| Mexico | Coefficient | − 0.091539[a] | 0.958187a | − 0.131820 | − 0.877813[a] | 1.581147[a]9.363492 |
| | *t* value | − 6.463444 | 17.80303 | − 1.751941 | − 6.199072 | |
| Netherland | Coefficient | 0.062768 | 0.674641[b] | − 0.305601 | − 0.064933 | 0.367574 |
| | *t* value | 0.943571 | 4.416665 | − 1.563180 | − 0.205964 | 0.525727 |
| New Zealand | Coefficient | − 1.040660 | 2.177737 | − 0.697512 | 7.450339[c] | − 1.015917 |
| | *t* value | − 2.183748 | 1.628440 | − 2.121991 | 2.768065 | − 0.390925 |
| Norway | Coefficient | 0.180989[c] | 1.734231b | − 1.227700[b] | 0.126096 | 3.388734[a] |
| | *t* value | 2.701921 | 4.659972 | − 3.892491 | 0.170432 | 9.798508 |
| Portugal | Coefficient | − 0.040245 | 3.204917[b] | − 2.246728 | − 0.062649 | 1.410778 |
| | *t* value | − 0.044667 | 4.791542 | − 0.728300 | − 0.013375 | 0.177841 |
| Sweden | Coefficient | 0.436314a | 0.366749 | − 3.810993[a] | 8.452917[a] | 0.933871 |
| | *t* value | 10.03504 | 1.467712 | − 6.986516 | 6.244060 | 0.405051 |
| Spain | Coefficient | 0.255167 | 2.505355[a] | − 1.154066[b] | − 1.660640[c] | 0.868782 |
| | *t* value | 1.085714 | 18.02830 | − 3.362363 | − 2.607415 | 0.535505 |
| Switzerland | Coefficient | 0.205520 | 1.765544 | − 0.940071 | − 0.700219 | 1.429420 |
| | *t* value | 0.270085 | 2.253508 | − 1.282774 | − 1.634888 | 0.925766 |
| Turkey | Coefficient | − 0.024634[a] | 0.363732[b] | 0.831794[a] | − 0.121551[b] | − 0.683180[a] |
| | *t* value | − 10.87828 | 5.014510 | 14.66380 | − 4.451739 | − 17.37528 |
| United kingdom | Coefficient | 0.099599b | 0.819433[a] | 0.199821[b] | 0.488526[c] | − 2.548347[a] |
| | *t* value | 8.777961 | 45.55397 | 8.508964 | 3.771726 | − 43.84542 |
| United states | Coefficient | 0.070214 | 2.221765b | − 0.322474[c] | − 1.406972 | 5.035505[c] |
| | *t* value | 1.537866 | 8.390842 | − 3.263314 | − 2.782921 | 3.243310 |

[a] 1% level of significance

[b] A 5% level of significance

[c] 10% level of significance

developed financial departments of a country are a positive sign for environmental safety and regarded as a critical factor. Improvements in the financial department should be enforced step by step with great caution. For example, the financial sector should be protected from political influence to discourage the issuance of loan on the basis of political background.

Human development index has a positive and significant influence on environment protection in OECD countries.The sustainable and healthy environment can be created only along with the help of healthy life, education, and gross national income. The government should enroll students in the education sector and facilitate public sector institutions. Educated labor can play a vital role to construct a healthy society devoted to safeguarding environmental integrity. Policy recommendations have been suggested as following:

1. Spread awareness among masses and communities about their civic engagement in protecting the environment from further degradation;
2. Development of education initiatives leading to the emergence of an ecological approach which recognizes environmental well-being as an essential component of health;
3. Promoting, facilitating, and publicizing integrated solutions to local environmental problems as models of good practice;
4. Supporting local, regional, national, and international ecological strategies (such as world conservation strategy) as also being health issues;
5. Encourage monitoring and health impact assessment of new technology development;
6. Adopting an inter-sectoral approach to urban and regional planning which incorporates health concerns relative to industrial in both the physical and social environment.

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