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RESEARCH ARTICLE

The environmental impacts of financial development in OECD countries: a panel GMM approach

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Abstract
Financial development is often expressed as a private sector initiative earmarked towards motivating economic growth and mitigating poverty. Nonetheless, the need for economic development accompanied by high industrialisation and commercialisation strategies has generated natural environmental effects which have raised enormous concern to green interest groups about whether all the seventeen sustainable development goals will be achieved. This paper investigated the environmental effects of financial development in OECD countries from 2001 to 2012 by employing static models and system GMM analysis. The study utilised foreign direct investments, domestic credit to private sector by banks and domestic credit to private sector as the three proxies of financial development. The effects of these measures of financial development were examined on carbon emissions and greenhouse gases (indicators of environmental quality) and environmental sustainability. In this setting, the findings of the research spotlight that domestic credit to private sector by banks shows a negative and significant relationship with carbon emissions, greenhouse gases and sustainability. Conversely, domestic credit to private sector and economic growth indicates a positive and statistically significant relationship with carbon emissions, greenhouse gases and sustainability. Foreign direct investment is positive and significantly connected with carbon emissions and sustainability but only shows a positive and not significant link with greenhouse gases. The evidence suggested by this analysis adds that the financial system should continue to add more initiatives which consider natural environmental perspectives in their current operations. This present study also confirms the existence of the environmental Kuznets curve (EKC) in carbon emissions (turning point, $109,820), total greenhouse gases (turning point, $74,280) and sustainability (turning point, $112,505). The finding that the turning point of carbon emissions is higher than that of total greenhouse gases indicates why introducing initiatives designed to curb growth of carbon emissions in the respective OECD economies is important.

Keywords Financial Development · Carbon emissions · Greenhouse gases · Environmental sustainability · Economic growth

Introduction

Financial development is largely based on minimising costs of the financial system (entities, instruments, markets, legislation models which allow transactions to be conducted through offering credit) operations (Huang 2010). In this regard, financial development is promoted when the financial sector moderates and/or effortlessly reduce the impacts of information, transaction expenses and compliance in providing its major key functions (investment options and allocation of capital, deploying and pooling savings, fostering commodity exchange, risk management and facilitating trading) (Svirydzenka 2016). It is therefore vital to note that meaningful financial development stimulates the financial sector to improve the incorporation of environmental risks and deliver broadened investment for sustainable development as well as stimulate adoption of sustainable practises through the rest of the economy.

As such, it is equally critical to assess the influence of financial development on environment as it has been found to add emissions in diverse ways. For instance, financial

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entities offer loan facilities to their clients who end up purchasing automobiles, electrical and mechanical devices and equipment which emits different types of emissions. Moreover, financial intermediaries also motivate their customers (through relaxing access to credit facilities they offer) which inevitably stimulate such clients to invest in projects which have reduced transaction costs, yet they directly increase emissions (Zhang and Zhang 2018). In addition, foreign-based investment in form of foreign direct investment (FDI) is also found to stimulate economic growth which contributes to increased emissions (Sarkodie and Strezov 2019).

Evidently, in the past decades, both developed and developing countries have experienced increased environmental degradation owing to the negative effects that carbon emissions along with other greenhouse gases have imposed on the natural state of the environment (Ganda and Ngwakwe 2013). For instance, the consumption of non-renewable fuel sources together with unsustainable anthropogenic practises has largely contributed to increase in the levels of emissions which has inevitably resulted in severe climate changes (such as droughts, desertification, cyclones, earthquakes, heat waves) along with lowered standards of living of the affected people. Although environmental deterioration has continued, many countries in the Organisation for Economic Co-operation and Development (OECD) have shown high economic growth (Hurriyet 2018). Thus, since financial development spurs economic growth (Farhani and Ozturk 2015; Lee 2013), the influences of financial development on diverse environmental quality indicators along with sustainability require an investigation. For example, most studies have only focused on carbon emissions as the proxy of environmental quality (Katircioğlu and Taşpinar 2017; Javid and Sharif 2016; Dogan and Turkekul 2016; Ali et al. 2017; Khan et al. 2014) but no concentration has been given on total greenhouse gases. Moreover, research which examines the link between financial development and sustainability has been non-existent.

The relationship between financial development and emissions has been an active study field (Katircioğlu and Taşpinar 2017; Dogan and Turkekul 2016; Farhani and Ozturk 2015; Shahbaz et al. 2013; Tang and Tan 2015; Dinh and Shih-Mo 2014; Destek and Sarkodie 2019). Since there is very little analysis on the simultaneous effect of financial development on environmental quality and sustainability, this present study proposes to make contribution to current literature by investigating the simultaneous relationship between financial development and environmental quality and sustainability in OECD countries. Thus, findings in relation to environmental quality and environmental sustainability in OECD countries will be compared and contrasted. This paper is also unique in the sense that it decomposes financial development into three proxies commonly adopted by the World Bank, namely FDIs, domestic credit to private sector by banks and domestic credit to private sector and then deploys carbon emissions and total greenhouse gases as indicators of environmental quality, and employs national adjusted net savings (excluding particulate emission damage) as the measure for environmental sustainability. Although recent studies by Danish et al. (2018) and Alam et al. (2015) disintegrated financial development into different proxies their surveys put emphasis on the nexus between energy consumption and financial development which is not the aim of this study. In this regard, knowledge on the association between financial development and environmental quality and sustainability in OECD countries is vital to aid these countries find out if existing financial development activities consider natural environmental interests vital to create green economies. As well most OECD countries consist of highly industrialised countries, emerging economies along with developing countries which were affected by diverse financial crises such as Asian financial crisis for the time of 1997–1998, European exchange rate crisis during 1992–1993 and the global financial crisis in the course of 2007–2008. Therefore, reports demonstrate that there are initiatives to bring reforms within the respective financial system of these economies. In that case, financial sector reform coupled with its growth indicates that most financial entities in the OECD economies consist of viable tier 1 capital ratios (OECD 2015). On that note, there is urgent need to test the relationship between financial development and environmental quality and environmental sustainability.

In addition, the other objective of the paper is to investigate if the environmental Kuznets curve (EKC) exists for carbon emissions, greenhouse gases and environmental sustainability in OECD countries. In this case, further extension on current analysis of EKCs using diverse environmental measures is supported using recent data thereby providing contexts which compare empirical results with past studies. This present study will also make use system generalized method of moments (GMM) which is a dynamic estimator that corrects heteroscedasticity, serial correlation and cross-sectional dependence unlike application of solely static models (random effects, fixed effects and ordinary least squares (OLS)) which are unable to successfully eliminate heterogeneity problems. In this case, more efficient estimates through use of system GMM are expected when compared to earlier studies which have entirely relied on static models. Moreover, the study will not employ other types of econometric models (panel cointegration techniques, panel unit methods, ARDL methods) since the system GMM approach adopts a standard growth model. As such, this technique indicates the existence of a strong conceptual framework, as it will estimate short-term variable's sensitivity to a change in another variable, and not the long-term elasticities. As such, the process concludes that through investigating the time dimension in a dynamic framework, the researcher is able to understand how natural environmental changes influence financial development in transition. Consequently, by employing the dynamic panel, we permit current financial development performance to be influenced by past financial development performance which is a common characteristic of financial processes.

The remainder of the article is organised as follows. The "Literature review" section outlines literature on the EKC hypothesis together with financial development and environmental quality nexus. The "Research methodology" section presents the data and research methodology of the study. The paper's results are given in the "Empirical results" section. The "Conclusion" section concludes the study.

Literature review

The paper presents literature on the EKC hypothesis and the associated empirical studies.

The EKC hypothesis

The systematic association involving income change along with environmental quality has been referred to the EKC as suggested by Kuznets (1955) who predicted that the relationship is an inverted U-shaped curve. Dinda (2004: 432) expresses that "… EKC hypothesis posits a well-defined relationship between level of economic activity and environmental pressure (defined as the level of concentration of pollution or flow of emissions, depletion of resources, etc.)". Thus, the EKC demonstrates that economic advancement results in increased environmental damage, but after a particular level of economic development, the society begins to experience improved relationships with the natural environment plus the rate of environmental deterioration declines. In this case, economic growth is perceived as beneficial for the natural environment (Pao and Tsai 2011; Ganda 2018). The justification for the EKC hypothesis is based on current evidence showing decreasing pollution with economic growth, availability of people's extra disposable income with economic growth causing them to be more natural environmentally oriented, better technological facilities, adoption of green energy, imposition of environmental regulations and de-industrialisation (shifts from manufacturing-based economy to a service sector) (Dinda 2004; Katircioğlu and Taşpinar 2017; Ali et al.2017; Seker et al. 2015; Javid and Sharif 2016). Nonetheless, critics of the EKC suggest that there is no assurance that economic growth results in a better natural environmental setting, in fact, a damaged environment is generated. For instance, Arrow et al. (1996) posit that the emission-income advancement of agrarian sectors to industrial economies to service institutions will probably produce false outcomes if pollution heightens at the end as a result of high-income levels along with consumption of the whole population. As such, it is highlighted that a well-defined environmental policy along with positive attitudes which permit economic growth is imperative to harmonise with an improving natural environment. On that note, diverse empirical studies have found the EKC valid in some countries but invalid in others. Table 1 outlines selected literature indicating the validity and/or non-validity of the EKC in different countries.

Table 1 demonstrates a range of studies which show mixed results about financial development and environmental quality. It is also clear that these surveys employed various econometric approaches, time periods and countries. A common aspect of these studies indicates that they have included at least one financial development proxy (which shows that this variable is an important part to spur improved natural environmental status) in their analysis and have also used carbon emissions as indicator of environmental quality. This paper decomposes financial development into three proxies, employs two measures of environmental quality and also, analyses environmental sustainability contexts.

Research methodology

This section outlines comprehensive details of the data and regression model(s) adopted by the paper.

Data characteristics

The study considered twenty-three OECD countries for the period 2001 to 2012. These countries are Argentina, Belgium, China, Czech, Estonia, France, Germany, Hungary, Ireland, Italy, Japan, Korea, Netherlands, Poland, Portugal, Romania, Russia, Slovenia, South Africa, Spain, Turkey, UK and US. Table 2 outlines the variables deployed in the paper together with their sources.

From Table 2, the logarithm of per capita carbon emissions, logarithm of total greenhouse gas and logarithm of adjusted net savings (excluding particulate emission damage) indicates the dependent variables. The remaining variables are all explanatory variables. All the variables were extracted from the World Development Indicators (World Bank) database.

Table 3 provides an extensive analysis about the attributes of the variables of the paper. It illustrates that the mean as well as the standard variables of the analysed variables is found between their respective minimum along with maximum values. Furthermore, most of these factors are negatively skewed (88%) but only 12% demonstrates positive skewness. More elaborately, carbon emissions, adjusted net savings (excluding particulate emission damage), FDI, domestic credit to private sector by banks, domestic credit to private sector and GDP per capita are negatively skewed. Conversely, total greenhouse gases are the only variable that is positively skewed. In relation to kurtosis, all the variables have leptokurtic characteristics owing to their positive estimates generated by the analysis.

Table 1 Empirical literature

Author(s)	Country(s)	Period	Variables	Methodology	Result(s)
Katircioğlu and Taşpinar (2017)	Turkey	2001–2008	Carbon dioxide emissions; economic growth (GDP); financial development; energy use (E)	DOLS approach; Granger causality tests and variance decomposition techniques	Financial development negatively moderates the impact of real output on carbon dioxide emissions in the shorter periods negatively, but positively moderates in the longer periods. EKC holds.
Javid and Sharif (2016)	Pakistan	1972–2013	Carbon dioxide emissions (CO_2); economic growth (GDP); financial development (FD); energy use (E)	The bound *F* test for cointegration	Financial development is positively related to emissions. Economic growth (GDP) and energy use (E) significantly add to emissions. EKC holds.
Apergis and Ozturk (2015)	14 Asian countries	1990–2011	CO_2 emissions; GDP; population density; land, industry shares and quality of institutions	The GMM methodology	EKC was found between emissions and income.
Ali et al. (2017)	Malaysia	1971–2012	GDP, FD, trade openness, foreign direct investments (FDI), E and CO_2	Autoregressive distribute lagged (ARDL) bound test, dynamic ordinary least squares (DOLS) method and Granger causality test	E ↔ CO_2 and other remaining variables show unidirectional association with CO_2. EKC is valid.
Dogan and Turkekul (2016)	USA	1960–2010	CO_2 emissions, GDP, E, trade (T), urbanisation (U) and FD	The bound testing for cointegration; Granger causality test	In the L/R, E and U lead to high emissions, but no effect on FD while trade leads to improved environmental quality. EKC did not hold. CO_2 ↔ GDP; CO_2 ↔ E; CO_2 ↔ U; GDP ↔ T. No causality between CO2 and T, CO_2 and FD.
Al-Mulali et al. (2015)	93 countries	1980–2008	Ecological footprint, E, GDP, TR, FD, U	The GMM methodology	E, T and U add to ecological footprint; FD reduces ecological footprint. EKC holds for high-income countries.
Pao and Tsai (2011)	BRIC countries	1992–2007	CO_2, E, GDP, FD	Ordinary least squares (OLS), vector error correction model (VECM) causality	FD and E add to CO_2. Also E ↔ GDP and GDP ↔ CO_2. EKC holds.
Jalil and Feridun (2011)	China	1953–2006	CO_2, E, GDP, FD, T	ARDL test, VECM approach	E and T add to CO_2, FD minimises CO_2. EKC is valid.
Shahbaz et al. (2013)	Malaysia	1971–2011	CO_2, E, GDP, FD, T	ARDL test, VECM technique	E and GDP add to CO_2. TR and FD reduce CO_2; GDP ↔ CO_2; E ↔ CO_2, FD ↔ CO_2. EKC was not examined.
Farhani and Ozturk (2015).	Tunisia	1971–2012	CO_2, E, GDP, T, FD, U	Dickey–Fuller *t* test (DF-GLS test), ARDL bound test, VECM causality	E, T, FD and U add to CO_2; GDP, EC, FD, TR, U ↔ CO_2. EKC is not valid.
Shahbaz et al. (2015)	99 nations	1975–2012	CO_2, E, GDP, FD	Pedroni and Johansen cointegration, fully modified ordinary least squares (FMOLS), DH causality	E and GDP add to CO_2, higher FD minimises CO_2; FD ↔ CO_2, E ↔ CO_2, GDP → E. EKC not evaluated.
Seker et al. (2015)	Turkey	1974–2010	CO_2, E, GDP, FD	Hatemi-J cointegration, ARDL bound test, VECM approach	E and FD add to CO_2; EC, GDP ↔ CO_2; FD ↔ CO_2. EKC holds.
Tang and Tan (2015)	Vietnam	1976–2009	CO_2, E, GDP, FD	Johansen cointegration, VECM approach	E adds to CO_2; FD minimises CO_2; GDP ↔ CO_2, E ↔ CO_2, FD ↔ CO_2, GDP → E, E → FD. EKC was found.
Omri and Kahouli (2014)	54 countries	1990–2011	GDP, FDI, CO_2	Dynamic simultaneous equation models	GDP and FDI have positive effect on CO_2. EKC not investigated.
Lee (2013)	G20 countries	1971–2009	GDP, FDI, CO_2	Panel cointegration approach	

Table 1 (continued)

Author(s)	Country(s)	Period	Variables	Methodology	Result(s)
					FDI → GDP and FDI → CO_2. EKC not investigated.
Asghari (2013)	MENA region	1980–1911	GDP, FDI, CO_2	Random effects and fixed effects approaches	GDP contributes to emissions. FDI lessens emissions.
Tamazian and Rao (2010)	24 transition economies	1993–2004	GDP, FDI, E, CO_2	The GMM methodology	GDP and E heighten CO_2. FDI lessens emissions. EKC holds.
He et al. (2012)	China	1985–2010	GDP, FDI, E, CO_2	Multivariate VAR model	GDP → E and GDP → FDI. E → FDI. EKC not examined.
Dinh and Shih-Mo (2014)	Vietnam	1980–2010	GDP, FDI, E, CO_2	Cointegration approach, Granger causality test	GDP and E increase CO_2. FDI reduces emissions. CO_2 → FDI. EKC is not valid.
Khan et al. (2014)	Non-OECD, OECD, South African and MENA countries	1975–2011	GDP, FDI, E, CO_2	Panel cointegration technique and seemingly unrelated regression (SUR) method	Positive impact of FDI and GDP on E was found. EKC not investigated.

→ means Granger unidirectional relationship, ↔ means Granger bidirectional relationship. *S/R* short run, *L/R* long run

Regression framework

With reference to surveys conducted by Twerefou et al. (2017), Halkos (2003) and Taguchi (2012), a dynamic panel regression framework which integrates a lagged dependent variable in the standard EKC equation to generate a modified EKC model is employed as indicated below:

$$EZ_{it} = \alpha_1 + \alpha_2 EZ_{it-1} + \alpha_3 \text{Log}GDP_{it} + \alpha_4 \text{Log}(GDP)^2_{it} + \alpha_5 \text{Log}FDI_{it} + \alpha_6 \text{Log}FDB_{it} + \alpha_7 \text{Log}FDP_{it} + \varepsilon_{it} \quad (1)$$

and more specifically,

$$\text{Log}EMI_{it} = \alpha_1 + \alpha_2 \text{Log}EMI_{it-1} + \alpha_3 \text{Log}GDP_{it} + \alpha_4 \text{Log}(GDP)^2_{it} + \alpha_5 \text{Log}FDI_{it} + \alpha_6 \text{Log}FDB_{it} + \alpha_7 \text{Log}FDP_{it} + \varepsilon_{it} \quad (1.1)$$

$$\text{Log}GHG_{it} = \alpha_1 + \alpha_2 \text{Log}GHG_{it-1} + \alpha_3 \text{Log}GDP_{it} + \alpha_4 \text{Log}(GDP)^2_{it} + \alpha_5 \text{Log}FDI_{it} + \alpha_6 \text{Log}FDB_{it} + \alpha_7 \text{Log}FDP_{it} + \varepsilon_{it} \quad (1.2)$$

$$\text{Log}ANS_{it} = \alpha_1 + \alpha_2 \text{Log}ANS_{it-1} + \alpha_3 \text{Log}GDP_{it} + \alpha_4 \text{Log}(GDP)^2_{it} + \alpha_5 \text{Log}FDI_{it} + \alpha_6 \text{Log}FDB_{it} + \alpha_7 \text{Log}FDP_{it} + \varepsilon_{it} \quad (1.3)$$

where Eq. (1) is the generalised MEKC with EZ_{it} representing all the dependent variables for country i over period t expressed in the logarithm function (the log function provides a very realistic income-environmental effect (quality, sustainability) path when compared to the level functions owing to symmetric attributes of the latter (Cole et al. 1997)). These dependent variables are logarithm of per capita carbon emissions (LogEMI_{it}) and logarithm of total greenhouse gas (LogGHG_{it}) which are indicators of environmental quality while logarithm of adjusted net savings (excluding particulate emission damage) (LogANS_{it}) is a proxy of environmental sustainability. EZ_{it-1} is the lagged dependent variable by one year. It was deployed to integrate dynamism in the model as it permits for partial adjustment of the dependent variable to its long-run equilibrium (Tamazian and Rao 2010; Twerefou et al. 2017). The proxies of financial development are namely LogFDI_{it} the logarithm of FDIs, LogFDB_{it} the logarithm of domestic credit to private sector by banks and LogFDP_{it} the logarithm of domestic credit to private sector. Other explanatory variables are LogGDP_{it} the logarithm of GDP per capita and Log $(GDP)^2_{it}$ the logarithm of squared GDP per capita. ε_{it} is the error term. Equations (1.1)–(1.3) show specific MEKC equations that are particular to the dependent factors analysed in this paper.

Equation (1), and hence its sub-equations (1.1)–(1.3), permits conditions to investigate the different types of pollution-income relationships. More particularly:

- When $\alpha_3 > 0$ and $\alpha_4 = 0$, then a monotonically increasing linear association that demonstrates that heightening incomes are associated with rising levels of carbon emissions exists.

Table 2 Profiles of variables

Variable	Definition	Unit adopted	Source
Log*EMI*	Logarithm of CO_2 emissions	Metric tons per capita	World Development Indicators (World Bank)
Log*GHG*	Logarithm of total greenhouse gas. In order to convert this variable to per capita values, the total population of the country was used. The formula is as follows: total greenhouse gas emissions/total population.	kt of CO_2 equivalent per capita	World Development Indicators (World Bank)
Log*ANS*	Logarithm of adjusted net savings, excluding particulate emission damage. In order to convert this variable to per capita values, the total population of the country was used. The formula is as follows: adjusted net savings (excluding particulate emission damage)/total population.	Current US$ per capita	World Development Indicators (World Bank)
Log*FDI*	Logarithm of foreign direct investment	Net inflows (% of GDP)	World Development Indicators (World Bank)
Log*FDB*	Logarithm of domestic credit to private sector by banks (% of GDP)	% of GDP	World Development Indicators (World Bank)
Log*FDP*	Logarithm of domestic credit to private sector	% of GDP	World Development Indicators (World Bank)
Log*GDP*	Logarithm of GDP per capita	PPP (current international $)	World Development Indicators (World Bank)

- When $\alpha_3 < 0$ and $\alpha_4 > 0$, then the existence of a U-shaped relationship is supported, and
- When $\alpha_3 > 0$ and $\alpha_4 < 0$, an inverted U-shaped relationship is valid which confirms the presence of the EKC and the turning point is, $Y^* = \exp(\frac{-\alpha_3}{2\alpha_4} \frac{-\alpha_3}{2\alpha_4} \frac{-\alpha_3}{2\alpha_4})$.

This paper utilises the generalized method of moments (GMM) approach as it is a dynamic model which is able to control problems of endogeneity, Nickell bias, measurement error, heteroskedasticity, unobserved individual heterogeneity and simultaneous reverse causality when compared to other analysis techniques (Apergis and Ozturk 2015; Taguchi 2012). Moreover, this technique is appropriate in situations when the number of cross-sectional units (N) is larger than the time period (T). This paper has $N = 23$ and $T = 12$; therefore, the dynamic panel GMM estimator is absolutely suitable. The dynamic GMM technique was initially proposed by Arellamo and Bond (1991) who used the first difference estimator but with time the approach was adopted by Blundell and Bond (1998) who integrated the level and first difference series as instruments to obtain the system GMM estimator. This study will employ the system GMM as it is more efficient (makes use of both levels along with the first difference series to handle challenges of weak instruments) when compared to the first difference estimator (generates poor results when lagged levels of a persistent series prescribe weak instruments for the successive first difference series) (Bujari et al. 2017; Oseni 2016). Furthermore, this study deploys the two-step system GMM estimator than the one-step system GMM as the former generates more asymptotic efficient values especially in situations where heteroskedasticity problems are heavily embedded in the one-system GMM (Berk et al. 2018; Oseni 2016). The Hansen tests will be used to test validity of the instruments and failure to reject the null hypothesis indicates that the model has wrong specifications (Apergis and Ozturk 2015; Twerefou et al. 2017). In addition, the first-order auto-correlation presence along with the second order auto-correlation absence will also add to confirm

Table 3 Statistical summary of variables

Variable	Min.	Max.	Mean	Std. dev.	Skewness	Kurtosis	Observation
Log*EMI*	0.4380866	1.293548	0.8958061	0.1762625	− 0.2733096	2.729947	276
Log*GHG*	− 2.393006	0	− 1.939269	0.3071369	4.496678	29.22335	276
Log*ANS*	0	3.959153	2.924027	0.8981811	− 2.086897	7.299863	276
Log*FDI*	− 2.774832	1.941723	0.4398962	0.5533127	− 0.9613781	8.040128	276
Log*FDB*	− 0.7308309	2.288668	1.764977	0.4318734	− 2.345997	10.88629	276
Log*FDP*	− 0.7307897	2.314505	1.81307	0.4551391	− 2.190429	9.801063	276
Log*GDP*	3.508779	4.711386	4.351772	0.2367117	− 0.9526743	3.572282	276
Log$(GDP)^2$	12.31153	22.19716	18.99375	2.008244	− 0.8169109	3.183994	276

validity of the model (Cao et al. 2015). It must be emphasised that only confirmation of the fixed effects (FE) model after the Hausman tests will permit application of the system GMM technique.

Lastly, the time-series data will employ unit root tests such as augmented Dickey–Fuller (ADF), Levine-Lin-Chu (LLC) and Phillips–Perron (PP) panel unit root tests which are the first-generation panel unit root tests. The second-generation test employed by this article is CADF (Pesaran 2003). The primary difference involving the first- and second-generation tests rests in the cross-sectional independence assumption. In this context, the first-generation tests assert that cross sections are independent while second-generation tests relax the assumption. As such, second-generation tests are vital in situations where co-movements have been identified in the national cycle under observation for selected countries which belong to a particular economic area. Moreover, cross-section dependence is also generated through worldwide similar shocks with varied influence across countries. Likewise, it can be produced from local spillover impacts involving countries and/or regions. In this article, I employ the Pesaran (2004) CD-test which uses the correlation coefficient involving the time series for the variables in the study. The procedure is robust to forms of non-stationarity, variable differences or structural breaks and is also applicable to small samples (Pesaran 2006).

Empirical results

The findings of the paper as well as their discussion are presented in this section.

Table 4 shows that having applied ADF, LLC and the PP test, the time series is free of unit root presence that may lead to errant conduct along with spurious regressions. Thus, by employing a null hypothesis that a particular time series is non-stationary all the variables indicate that they are stationary at the first-order differenced series for all ADF, LLC and PP tests (at 1% significant level) using the first-generation panel unit roots.

However, the conventional assumption in panel data frameworks is that the error terms are independent across cross sections. In that regard, findings illustrated in Table 5 indicate that at 1% significance level, the null hypothesis of cross-sectional independence in this paper's panelised data should be rejected for all variables.

To get rid of this form of dependence, standard regressions are augmented with the cross-section averages of lagged levels and the first differences of the individualised series (CADF statistics). In that case, controlling for cross-section dependence, the prior outcomes are to an extent confirmed by results shown in Table 6. In this context, the null hypothesis that all series are non-stationary holds for both constant, and for constant and trend thereby agreeing with outcomes shown by ADF, LLC and PP tests. Hence, through considering the cross-sectional correlations, the outcomes of the paper outline that the panelised data is stationary. This finding which confirms stationarity demonstrates that it is possible for the series to forecast and/or predict future shifts in either the emissions and/or sustainability relationship based on historical behaviour.

The paper initially outlines the outcomes of the static models. Therefore, the findings of the pooled ordinary least squares (OLS), fixed effects (FE) and random effects (RE) regressions for each dependent variable are presented below.

Table 7 indicates the findings of the paper using static models (OLS, FE and RE) by deploying logarithm of carbon emissions as the dependent variable. Since the Hausman test shows that the chi-square estimate is 13.99 and is significant at 5% level ($p = 0.01570157 < 0.05$), it means we reject the null hypothesis which states that the RE model is appropriate in favour of the alternative hypothesis which explains that the FE model is appropriate. In this case, we analyse this static model further by introducing dynamism through the two-step GMM model.

Table 8 indicates the results of the paper using static models (OLS, FE and RE) by employing logarithm of greenhouse gas as the dependent variable. Since the Hausman test illustrates that the chi-square estimate is 2.93 and is not significant at 10% level ($p = 0.7104 > 0.10$), it means we accept the null hypothesis which states that the RE model is appropriate and reject the alternative hypothesis which explains that the FE model is appropriate. In this case, we do not analyse this static model further by introducing dynamism through the two-step GMM model since the RE model has already accounted for individual effects. More elaborately, the RE model assumption is that the individual country specific effects are uncorrelated with the independent variables (Gujarati and Porter 2009; Wooldridge 2013). As such, since the assumption of the RE model results held against the FE model (proven by the Hausman test) on greenhouse gas emissions, the RE model is more efficient when compared to the FE model. Furthermore, the Breusch and Pagan Lagrangian multiplier test enhances the analysis to decide the appropriate model between a random effects regression and an OLS regression. It follows that using the null hypothesis that variances across entities is zero we found out that the Breusch-Pagan test (χ^2) = 186.79 and p value = 0.000. In this case, since p value < 5%, we reject the null hypothesis and conclude that RE model is appropriate since there is evidence of differences across the studied countries.

From the RE model in Table 8, domestic credit to private sector by banks illustrates a negative and significant relationship with greenhouse gases. Therefore, a percentage rise in Log*FDB* will result in a 1.14% decrease in greenhouse gases thereby concurring with Khan et al. (2017) survey outcomes

Table 4 ADF, LLC and PP panel unit root outcomes

	At level			At the 1st difference		
Variable	ADF statistic	LLC statistic	PP statistic	ADF statistic	LLC statistic	PP statistic
Log*EMI*	− 1.9699	− 1.7994	− 1.9699	24.7525	− 6.0239	24.7525
	(0.9756)	(0.0360)	(0.9756)	(0.0000)***	(0.0000)***	(0.0000)***
Log*GHG*	− 1.1955	− 3.7037	− 1.1955	28.2495	− 6.3561	28.2495
	(0.8840)	(0.0001)	(0.8840)	(0.0000)***	(0.0000)***	(0.0000)***
Log*ANS*	6.4266	− 3.7687	6.4266	26.7211	− 3.5294	26.7211
	(0.0000)***	(0.0001)***	(0.0000)***	(0.0000)***	(0.0002)***	(0.0000)***
Log*FDI*	9.2879	− 4.8735	9.2879	38.5016	− 7.6061	38.5016
	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***	(0.0000)***
Log*FDB*	− 0.2076	− 7.9480	− 0.2076	14.5298	− 4.7116	14.5298
	(0.5822)	(0.0000)***	(0.5822)	(0.0000)***	(0.0000)***	(0.0000)***
Log*FDP*	− 0.6229	− 7.9697	− 0.6229	15.1687	− 4.6101	15.1687
	(0.7333)	(0.0000)***	(0.7333)	(0.0000)***	(0.0000)***	(0.0000)***
Log*GDP*	− 1.5643	− 5.1587	− 1.5643	8.5067	− 5.5245	8.5067
	(0.9411)	(0.0000)***	(0.9411)	(0.0000)***	(0.0000)***	(0.0000)***
$\text{Log}(GDP)^2$	− 1.8703	− 4.6284	− 1.8703	8.8425	− 5.8459	8.8425
	(0.9693)	(0.0000)***	(0.9693)	(0.0000)***	(0.0000)***	(0.0000)***

***, ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are *p* values

on upper middle-income countries from Asia, Europe, Africa and America. In addition, domestic credit to private sector indicates a positive and statistically significant relationship with greenhouse gases. In this context, a 1% increase in Log*FDP* will lead to 1.134% increase in greenhouse gases. FDI relationship with greenhouse gases is positive but not significant. In addition, GDP per capita and GDP per capita squared also demonstrate statistically positive and negative associations with greenhouse gases respectively. This result is consistent with Lu (2017) study on 16 Asian countries using panel cointegration approach and Armeanu et al. (2018) research on 28 countries in the European Union. This paper also proves validity of the EKC for greenhouse gases in OECD countries with a turning point determined to be $74,280. Thus, the study outcomes agree with Cole et al. (1997) FE and RE model analysis on OECD and non-OECD countries.

Table 9 indicates the findings of the paper using static models (OLS, FE and RE) by employing logarithm of for adjusted net savings (excluding particulate emission damage) as the dependent variable. Since the Hausman test shows that the chi-square estimate is 13.27 and is significant at 5% level ($p = 0.0210 < 0.05$), it means we reject the null hypothesis which states that the RE model is appropriate in favour of the alternative hypothesis which explains that the FE model is appropriate. In this case, we analyse this static model further by introducing dynamism through the two-step GMM model.

Table 5 Panel cross-section dependence tests

Variable	CD-test statistic
Log*EMI*	8.74 (0.000)
Log*GHG*	6.63 (0.000)
Log*ANS*	15.72 (0.000)
Log*FDI*	9.34 (0.000)
Log*FDB*	20.02 (0.000)
Log*FDP*	18.41 (0.000)
Log*GDP*	53.45 (0.000)
$\text{Log}(GDP)^2$	53.41 (0.000)

The Pesaran (2004) CD-test for cross-section dependence in panel time-series data. *p* values in parentheses

Table 6 The panel unit root test in the presence of cross-section dependence tests

Variable	Constant	Constant and trend
Log*EMI*	4.832 (0.099)	− 2.698 (0.003)
Log*GHG*	− 3.314 (0.000)	− 3.058 (0.001)
Log*ANS*	− 3.860 (0.000)	− 6.465 (0.000)
Log*FDI*	− 4.799 (0.000)	− 5.144 (0.000)
Log*FDB*	− 3.840 (0.000)	− 1.648 (0.050)
Log*FDP*	− 4.454 (0.000)	− 1.702 (0.044)
Log*GDP*	− 1.335 (0.091)	− 1.231 (0.010)
$\text{Log}(GDP)^2$	− 1.024 (0.003)	− 1.003 (0.008)

z (*t* bar) statistics; *p* values in parentheses

Table 7 Estimates of static panel data for carbon emissions (Log*EMI*)

	Pooled model		Random effects model		Fixed effects model	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Log*FDI*	0.0694298 (0.000)***	0.015651	0.0166468 (0.004)***	0.0057531	0.0160333 (0.005)***	0.0056712
Log*FDB*	− 0.6386065 (0.000)***	0.0700463	− 0.3993948 (0.016)**	0.1662777	− 0.0849079 (0.176)	0.2327098
Log*FDP*	0.6331505 (0.000)***	0.0695188	0.4024566 (0.015)**	0.1661687	0.0892644 (0.701)	0.2325702
Log*GDP*	1.739516 (0.096)*	1.040525	5.917993 (0.000)***	0.4046224	6.096672 (0.000)***	0.4010435
Log$(GDP)^2$	− 0.1668033 (0.178)	0.1234498	− 0.696249 (0.000)***	0.0488282	− 0.7188607 (0.000)***	0.0484189
Constant	− 3.557314 (0.107)	2.200371	− 11.66565 (0.000)***	0.838942	− 12.0007 (0.000)***	0.8300397
R^2	0.4347		0.1395		0.0050	
Wald (χ^2)			269.63			
F statistic	41.52				55.53	
Breusch-Pagan test (χ^2)			1122.04 (0.000)***			
Hausman test (χ^2)					13.99 (0.0157)**	
No. of observations	276	276	276	276	276	276

***, ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are *p* values

The GMM results presented in Table 10 are more efficient for the dependent variables, carbon emissions and adjusted net savings (excluding particulate emission damage) (when compared to results in Tables 7 and 9), since the analysis supported their respective FE models. Hence, by evaluating outcomes in Table 10, it must also be noted that carbon emissions are a proxy for environmental quality which implies that a negative coefficient on a variable shows an increase in environmental quality or an improvement in state of the natural environment, and vice-versa. On the other hand, adjusted net savings (excluding particulate emission damage) are a measure for environmental sustainability which confirms that a negative coefficient on a variable illustrates deterioration in environmental sustainability, and vice-versa.

We first examine carbon emissions as the dependent variable. Table 10 shows that all variables indicate a positive and/or negative statistically significant relationship with carbon emissions. Firstly, the lagged variable (LogEMI_{it-1}) indicates a positive and significant association with emissions. Thus, a 1% rise in lagged carbon emissions results in a 0.45% rise in carbon emissions. This implies that a rise in previous carbon emissions would heighten current carbon emissions in the studied OECD countries. This finding supports global reports that show rapid increase of carbon emissions in the past few years (Canadell et al. 2007; Van Vuuren and Riahi 2008). Secondly, FDIs indicate a positive and statistically significant link with carbon emissions. As such, a percentage increase in Log*FDI* will result in 0.07% increase in carbon emissions. This outcome is in line with survey outcomes by (Zhang and Zhang 2018) on China although it contradicts with Dinh and Shih-Mo (2014) and Tamazian and Rao (2010) studies on Vietnam and 24 transition economies respectively. Thirdly, domestic credit to private sector by banks illustrates a negative and statistically significant connection with carbon emissions. In this vein, a 1% rise in Log*FDB* causes a 0.86% drop in carbon emissions. This paper's outcome is congruent with Xiong et al. (2017) survey on China's developed regions than the less developed areas. Fourth, domestic credit to private sector demonstrates a positive and statistically significant association with carbon emissions. As such, a 1% rise in Log*FDP* results in 0.76% increase in emissions. This outcome is confirmed by Shahbaz et al. (2013) research on Malaysia along with Boutabba (2014) survey of the Indian economy but it is not congruent with Salahuddin et al. (2015) long-run outcomes through an exploration of the Gulf Cooperation Council countries. Lastly, GDP per capita and GDP per capita squared show statistically positive and negative relationships with carbon emissions respectively. Hence, this finding validates the existence of the EKC hypothesis for carbon emissions per capita in OECD countries with a turning point of $109,820. As such, the outcome agrees with Katircioğlu and Taşpinar (2017) research on Turkey and Javid and Sharif (2016) survey on Pakistan but it disagrees with Farhani and Ozturk (2015) study of Tunisia over the period 1971–2012.

Table 8 Estimates of static panel data for total greenhouse gases (Log*GHG*)

	Pooled model		Random effects model		Fixed effects model	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Log*FDI*	1.1076546 (0.001)***	0.031621	0.0477985 (0.165)	0.0344351	0.0330603 (0.368)	0.0366281
Log*FDB*	− 1.204731 (0.000)***	0.1415202	− 1.138062 (0.000)***	0.3153225	− 0.4867839 (0.746)	1.502976
Log*FDP*	1.260933 (0.000)***	0.1404544	1.134912 (0.000)***	0.3142854	0.4597959 (0.760)	1.502075
Log*GDP*	7.834036 (0.000)***	2.102258	8.186625 (0.000)***	2.336152	8.362607 (0.001)***	2.590174
Log$(GDP)^2$	− 0.9250877 (0.000)***	0.2494157	− 0.9501999 (0.001)***	0.2796747	− 0.9589993 (0.002)***	0.3127175
Constant	− 3.557314 (0.000)***	2.200371	− 19.58778 (0.000)***	4.882727	− 20.10546 (0.000)***	5.360883
R^2	0.24		0.2196		0.1193	
Turning point			$74,280			
Wald (χ^2)			28.87			
F statistic	17.05				3.74	
Breusch-Pagan test (χ^2)			186.79 (0.000)***			
Hausman test (χ^2)					2.93 (0.7104)	
No. of observations	276	276	276	276	276	276

***, ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are *p* values

The second part of this section evaluates adjusted net savings (excluding particulate emission damage) as the dependent variable by using Table 10 outcomes. In this case, all the variables show significant associations with adjusted net savings, that is, environmental sustainability. For example, the lagged variable (LogANS_{it-1}) outlines a positive and statistically significant relationship with adjusted net savings. In this regard, a percentage increase in previous adjusted net savings will improve current adjusted net savings, and in fact environmental sustainability in the studied OECD nations by 0.15%. It is also apparent that a 1% rise in FDI and domestic credit to private sector leads to a statistically significant increase of 0.31% (thereby supporting Twerefou et al. (2017) survey outcomes on 36 sub-Saharan African countries) and 11.46% in environmental sustainability, respectively. However, the result on domestic credit to private sector by banks indicates that its 1% increase generates 12.69% decrease in environmental sustainability. In conclusion, GDP per capita and GDP per capita squared also demonstrate statistically positive and negative associations with adjusted net savings respectively, thereby implying the existence of the EKC hypothesis for adjusted net savings per capita in OECD countries (showing a turning point of $112,502).

Post-estimation analysis

By examining Table 10, it is evident that the first-order serial correlation for carbon emissions generates $z = -3.13$ and $\Pr > z = 0.002$ ($z = -1.80$ and $\Pr > z = 0.017$ for adjusted net savings); hence, it is rejected since $p < 0.05$ at 5% significance level but the second-order serial correlation produces $z = 0.43$ and $\Pr > z = 0.669$ ($z = 0.43$ and $\Pr > z = 0.669$ for adjusted net savings); hence, it is accepted since $p > 0.05$ at 5% significance level. This analysis validates the instruments deployed in this paper. In addition, the Sargan and Hansen tests for both dependent variables demonstrate that the model is not weakened by using numerous instruments since the null hypothesis (which explains that there are valid over identifying restrictions in the tests) is not rejected.

Discussion and implications

This paper produced consistent results on the analysis concerning environmental quality variables (carbon emissions and greenhouse gases). For instance, domestic credit to private sector by banks was found to be decreasing both carbon emissions and greenhouse gases in the OECD countries. This

Table 9 Estimates of static panel data for adjusted net savings (excluding particulate emission damage) (Log*ANS*)

	Pooled model		Random effects model		Fixed effects model	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Log*FDI*	− 0.0581523 (0.529)	0.092317	0.1513801 (0.118)	0.0967418	0.1886351 (0.063)*	0.1010098
Log*FDB*	0.7201027 (0.082)*	0.4131665	0.128045 (0.890)	0.9259338	− 7.105555 (0.088)*	4.144781
Log*FDP*	− 0.7693422 (0.062)*	0.4100548	− 0.0909025 (0.922)	0.9231814	7.105953 (0.070)*	4.142295
Log*GDP*	− 10.27196 (0.095)*	6.137515	1.142312 (0.862)	6.578402	− 0.3763153 (0.958)	7.142965
Log(*GDP*)^2	1.435569 (0.050)*	0.7281659	0.138273 (0.851)	0.7879807	0.3631068 (0.674)	0.8623862
Constant	20.50788 (0.115)	12.97883	− 4.801152 (0.727)	13.7413	− 2.760525 (0.852)	14.78379
R^2	0.2425		0.2196		0.0659	
Wald (χ^2)			28.87			
F statistic	17.29				11.11	
Breusch-Pagan test (χ^2)			231.98 (0.000)***			
Hausman test (χ^2)					13.27 (0.0210)	
No. of observations	276	276	276	276	276	276

***, ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are *p* values

shows that the financial entities of OECD countries have integrated environmental sustainability principles and standards which in this case must be supported so that continued improvement of environmental quality is achieved. For example, these banks could be declining possible non-green-based investment projects of companies along with permitting their clients to buy durable products that are environmentally compatible (green houses, hybrid cars and so forth) so that sustainable use of resources and also development is promoted. It follows that financial entities should put emphasis on dealing with environmental and even social risks, by strategic decision-making, along with through examining loan appraisal procedures on firms and projects that are characterised with high environmental as well as social performance with the aim of preserving their asset portfolios. In matters where minimising non-performing loan capacities is essential, financial institutions should screen and filter all defaulters through engaging both environmental plus social risk assessment activities.

In addition, financial institutions can also find prospects in novel areas where they can optimally innovate towards sustainability. For example, the new fields may be related to green energy, efficient energy, green technologies and cleaner production mechanisms along with financial activities which are aimed at women empowerment. For instance, there are reports that women do more in the area of sustainable development when compared to their male counterparts (Bayeh 2016). In that case, sustainable banking is a fundamental component of sustainability since financial entities should provide goods and services to clients after taking into consideration the environmental and social influence of their initiatives.

Furthermore, brand visibility is imperative in fostering corporate responsibility practises targeted towards protecting the natural environment. As such, practical schemes could be focused on issues of energy, green goals' participation and climate change as well as obtaining new customer bases who will inevitably heighten the financial institution revenues in their implementation and operation. As well, the financial sector can also set up a strong data collection system and analysis culture as well as supporting environmental compatible activities which will serve to create and sustain necessary connections which will ensure that their sustainability plans together with practises are suitably in line with the countries sustainable development goals.

However, FDIs and domestic credit to private sector were found to contribute to both carbon emissions and greenhouse gases. In this case, government policymakers should introduce measures that insure the international financing systems are adhering to environmental quality interest's guidelines. For example, governments can integrate polices which promote

Table 10 Two-step system GMM findings with (a) carbon emissions and (b) adjusted net savings (excluding particulate emission damage) as the dependent variables

	Carbon emissions (LogEMI_{it})		Adjusted net savings (excluding particulate emission damage) (LogANS_{it})	
	Coefficient	Standard error	Coefficient	Standard error
LogEMI_{it-1}	0.4534528 (0.000)***	0.0566382		
LogANS_{it-1}			0.1467825 (0.000)***	0.0300751
Log*FDI*	0.0745848 (0.000)***	0.0084966	0.3134552 (0.000)***	0.0329021
Log*FDB*	− 0.8616874 (0.013)**	0.3236603	− 12.69121 (0.000)***	0.8444813
Log*FDP*	0.7577494 (0.017)**	0.3051666	11.45941 (0.000)***	0.7406585
Log*GDP*	1.898267 (0.000)***	0.7960422	17.81401 (0.000)***	4.024053
Log$(GDP)^2$	− 0.201993 (0.031)**	0.093606	− 1.885998 (0.000)***	0.4610214
Constant	− 3.810321 (0.021)**	1.648595	− 37.32067 (0.000)***	8.751959
Turning point	$109,820		$112,505	
Wald (χ^2)	19,417.48 (0.000)		6567.91 (0.000)	
Arellano-Bond test for AR(1) in the first differences	$z = -3.13$ $\Pr > z = 0.002$		$z = -1.80$ $\Pr > z = 0.017$	
Arellano-Bond test for AR(2) in the first differences	$z = 0.43$ $\Pr > z = 0.669$		$z = 1.11$ $\Pr > z = 0.266$	
Hansen test of overidentifying. Restrictions	Chi-square = 13.93 Prob > chi2 = 0.834		Chi-square = 13.95 Prob > chi2 = 0.733	
Sargan test of overidentifying. Restrictions	Chi-square = 23.15 Prob > chi2 = 0.281		Chi-square = 1.46 Prob > chi2 = 0.482	

***, ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are *p* values

environmental disclosure. Moreover, there is a need to make sure that general credit systems which are provided to the private sector also meet sustainability principles. For instance, credit structures should support investments in cleaner technologies through providing interest discounts along with incorporating environmental friendly specifications in existing financial instruments and products. Furthermore, economic growth was ascertained to be adding towards high carbon emissions and greenhouse gases. In this case, country decision makers should introduce more stringent environmental policies and organisational structures (governments can also ensure that compliance with country environmental regulations on FDI is subjected to more strict scrutiny) in their pursuit of increased economic growth. Such activities will inevitably generate long-term benefits for reductions in both carbon emissions and greenhouse gases. As well, policy developers should promote adoption of new technologies and policies which support creation of green economies. In this vein, multilateral environmental agreements are an option. They are founded on political recognition that worldwide initiative must be adopted on global environmental challenges (for example, biodiversity loss, ozone layer depletion, climate change, acid rain and desertification) which can be difficult to manage solely based on specific country's actions. As such, multilateral environmental agreements play a significant role in influencing the structure of FDIs.

Moreover, while there has been growth of international environmental standards, scope and technical specification practises on how environmental sustainability and management can be organised require to be improved. Such initiatives will promote transfer of successful management initiatives along with environmentally friendly technologies by FDI. In addition, since FDI can be a result of activities by foreign-owned companies in host countries, there is a need to create environmental supply chains which adhere to specific green technical needs, training, international environmental disclosures and auditing procedures so that a strong environmental efficiency is promoted.

On the other hand, domestic credit to private sector by banks was discovered to be having a deterioration impact on environmental sustainability. This finding implies that while banks have supported efforts to minimise growth of emissions and greenhouse gases they may have also provided numerous inducements that are not backed up with suitable environmental benchmarks which spur environmental sustainability perspectives on their financing systems. This is of great concern since financial entities provide most of the finance required by companies and the industries. As such, the need to align the financial sector goals and model to align with the United Nations Sustainable Development Goals and Paris Climate Accord. Moreover, financial entities must also develop their policies and strategies in ways that they are compatible with national and regional models on sustainability which enhance them to establish global standards for sustainable banking. Besides, financial sector should also become signatories and incorporate goals for along with disclosing their contribution to the country's and global sustainable development targets. Thus, improved accountability and transparency of financial institutions are imperative which may also possibly challenge them to assume leading roles in the area of sustainability.

In that regard, financial entity leadership should establish a vision through insuring that sustainability matters are directly embedded in the organisation strategic vision. In this vein, the sustainability risks and returns should be optimally understood thereby creating opportunities to set up an integrated sustainability policy which generates long-run rewards, which is more comprehensive and is able to withstand stakeholder criticism. Moreover, developing suitable governance which demands accountability regarding sustainability matters across the financial institution is also equally vital. This involves incorporating environmental and social considerations in the corporate policy, integrating stand-alone strategies and reporting (e.g. climate change, water disclosures). As well, identifying needs for more resources, establishing specialised employees and targeted sustainability training at all corporate levels, adopting incentive inducements earmarked towards sustainability and discouraging resistance to change along with allocating particular sustainability roles and responsibilities across all the financial company's departments are equally important. In addition, one point to consider is that stakeholders are also interested in issues of sustainability. Therefore, the organisation should support clear, credible and transparent communication to its partners about its sustainable approach so that the stakeholder expectations in relation to their economic, social and natural capital investments are preserved.

Domestic credit to private sector and FDIs contribute effectively towards environmental sustainability. In this regard, OECD countries should continue to add more strategies that guarantee that the effect of financial development on the environment is reduced. Such policies include adoption of green technologies, promoting energy efficient innovations, integrating CCUS (carbon capture, utilisation and storage) facilities and improved evaluation of green financing structures. As well, economic growth adds to better environmental sustainability context which is a commendable aspect as achievement of sustainable development goals can be realised.

Lastly, the turning point of carbon emissions is quite high at \$109,820. This shows that the concentrations of carbon emissions in OECD countries are still increasing even in the highly industrialised countries. Moreover, the turning point of total greenhouse gases was found to be \$74,280, and hence lower compared to that of carbon emissions, \$109,820 (this finding concurs with Cole et al. (1997) findings). This scenario indicates that carbon emission control has shown to be difficult, possibly as a result of high fossil fuel use along with persistent adoption of environmentally incompatible human activities which undermines all zero-carbon policies and approaches. The turning point of environmental sustainability is \$112,505 which is higher than both carbon emissions and total greenhouse gases. While this outcome illustrates a minor improvement in environmental sustainability, especially against carbon emissions, OECD countries are required to continue increasing all sustainability practises so that the turning point takes place at a significantly higher level. Therefore, an additional measure which can be adopted by governments would be an investigation regarding corruption associated with the rule of law. Thus, a weakened law system which is susceptible to high levels of corruption can be avoided by introducing diversity (based on political affiliation, levels of education, race and gender amongst others) in management of government policies targeted for development. In addition, it is also vital for countries to consider and revise their own regulations that control corruption and align them to globally accepted sustainable development goals.

Conclusion

This study examined the environmental impacts of financial development in OECD countries from 2001 to 2012 using static models and system GMM analysis. The paper decomposed financial development and employed three proxies namely FDIs, domestic credit to private sector by banks and domestic credit to private sector. The effects of these financial developments were examined in relation to carbon emissions and greenhouse gases (indicators of environmental quality) and environmental sustainability. The findings of the paper highlight that domestic credit to private sector by banks shows a negative and significant relationship with carbon emissions, greenhouse gases and sustainability. On the other hand, domestic credit to private sector and economic growth indicates a positive and statistically significant relationship with carbon emissions, greenhouse gases and sustainability. FDI is significantly positively associated with carbon emissions and sustainability but only shows a positive and not significant link with greenhouse gases. The evidence suggested by this analysis adds that the financial system should continue to add more initiatives which consider environmental perspectives in their current operations. This present study also confirms the existence of the EKC in carbon emissions (turning point, \$109,820), total greenhouse gases (turning point, \$74,280) and sustainability (turning point, \$112,505). Therefore, this evidence which shows that the estimated turning point of carbon emissions is higher than total greenhouse gases illustrates the importance of introducing initiatives designed to curb growth of carbon emissions in the respective OECD economies. Future studies should be conducted by extending the proxies of both environmental quality and sustainability through integrating more variables. In addition, individual case studies on these countries can also be implemented. As well, research could also focus on interaction effects of financial development variables on both environmental quality and sustainability at country level and/or regional basis.

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