Foreign finance, economic growth and CO_2 emissions Nexus in OECD countries

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Abstract

Purpose – This study aims to examine the relationship between foreign finance, economic growth and CO_2 to investigate if the environmental Kuznets curve (EKC) exists as an empirical evidence in 32 selected Organization for Economic Co-operation and Development (OECD) countries.

Design/methodology/approach – This study used quantitative analysis to test two main hypotheses: *H1* is the U-shape relationship between foreign finance and environment, and *H2* is the N-shaped association between economic growth and environment. In doing so, this study used panel data techniques. The panel set contained 32 countries over the period from 1990 to 2015, with 27 observations for each country. This study applied a panel OLS estimator via fixed-effects control to address heterogeneity and mitigate endogeneity. Generalized method of moments (GMM) with fixed effects-instrumental variables (FE-IV) and diagnostic tests were also used.

Findings – The results showed that foreign finance and environmental quality have an inverted U-shaped association. The three proxies' foreign investment, foreign assets and remittance in the first stages contribute significantly to CO_2 emissions, but after the threshold point is reached, these proxies become "environmentally friendly" by their contribution to reducing CO_2 emissions. Also, a non-linear relationship denotes that foreign investment in OECD countries enhances the importance, as a proxy of foreign finance has greater environmental quality than foreign assets. Additionally, empirical results show that remittances received is linked to the highest polluted levels until a threshold point is reached, at which point it then helps reduce CO_2 emissions. The GMM and FE-IV results provide robust evidence on inverse U-shaped relationship, while the N-shaped relationship explains that economic growth produces more CO_2 emissions at the first phase of growth, but the quadratic term confirms this effect is negative after a specific level of GDP is reached. Then, this economic growth makes the environment deteriorate. These results are robust even after controlling for the omitted variable issue. The IV-FE results indicate an N-shaped relationship in the OECD countries.

Practical implications – Most studies have used different economic indicators as proxies to show the effects of these indicators on the environment, but they are flawed and outdated regarding the large social challenges facing contemporary, socio-financial economic systems. To overcome these disadvantages, the social, institutional and environmental aspects of economic development should also be considered. Hence, this study aims to explain this issue as a relationship with several proxies in regard to environmental, foreign finance and economic aspects.

Originality/value – This paper uses updated data sets for analyzing the relationship between foreign finance and economic growth as a new proxy for pollution. Also, this study simulates the financial and environmental future to show their effect on investments in different OECD countries. While this study

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enhances the literature by establishing an innovative control during analysis, this will increase to add value. This study is among the few studies that empirically investigate the non-linear relationship between finance and environmental degradation.

Keywords Economic growth, CO_2 emissions, OECD countries, Foreign finance

Paper type Research paper

1. Introduction

The economic growth activities of different countries affect global CO_2 emissions. This has led to several countries aiming to obtain clean energy and therefore shift environmental policy focus toward greenhouse gas emissions (GHGs), which has caused a rapid transformation on economy (Pegkas, 2015). This has become evident through several countries' adoption of sustainable development and has instigated a change in strategy regarding the management of environmental resources (Paramati *et al.*, 2017). Economic factors that can help achieve a clean environment include reducing capital costs and increasing foreign assets (Al Mamun *et al.*, 2018).

Climate financing refers to resources that promote resilient development by allocating finances to create conditions that support the adaptation and mitigation of a negative climate impact and promote scientific research using modern climate financing technologies (Fernandes and Paunov, 2012). Sustainable financing continues to attract significant global attention in regard to funding environmental and infrastructural initiatives effective financing (Maddison and Rehdanz, 2008).

The magnitude of the climate change challenge is important to the international community and requires reflection on pre-industrial production levels and consumption processes to encourage countries to adopt policies that stimulate investment and address possible climate change (Galeotti *et al.*, 2009).

In this context, governments in different countries need to provide companies substantial support to adapt of environment changes, especially in developing countries, which are directly affected by the accumulation of buried gases in the atmosphere (Salahuddin *et al.*, 2018). Hence, the magnitude of the fiscal challenge to achieve this transformation makes it difficult for climate financing to absorb resources, which is also dependent on the resources available to each country (Akbostanci *et al.*, 2009). Specifically, developing countries lack the necessary financial resources, institutional and policy systems and skills to effectively finance climate initiatives (Pao and Tsai, 2011).

Climate change is a highly inconsistent development issue with unbalanced effects according to a country's income development pathways (Hao and Liu, 2015). These effects are unbalanced because it is likely that climate change damage will be more severe in lower-income countries (Ozturk and Acaravci, 2010).

Therefore, high-income countries have aimed to aid developing countries in reducing negative climatechange impacts via the establishment of the Green Climate Fund and financing technology (Maddison and Rehdanz, 2008). However, the slow growth of climate financing in these countries has created a challenge regarding scientific financial targets (Zhang and Zhou, 2016).

The threat of climate change raises difficult questions regarding how to implement them and what infrastructure will be developed (Alfaro *et al.*, 2004). Many countries have begun to propose policies that stabilize current emission levels to achieve a clean environment, which includes the costs of mitigation and adaptation (Wang, 2009).

These countries also strategize on how to share the burden of funding based on country pollution levels that have caused current damage (Lee, 2009). Acharyya (2009) sought to

establish these standards by determining a country's capacity to financially contribute based on their gross domestic product (GDP) and emission levels.

All multi-lateral development banks (MDBs) announced ambitious, multi-year targets in late 2015 involving the rapid expansion of climate financing activities to support the adaptation and mitigation in developing countries and emerging economies, adding to the momentum set by the Paris Agreement (Koçak and Şarkgüneşi, 2018). Moreover, MDBs are expanding in several relevant activities such as institutional capacities, technical support and providing access to the financial system (Pao and Tsai, 2010). The Paris Agreement indicates that progress beyond previous effort regarding the flow of finance is needed to support a path for adapting to climate change and reducing GHGs (Ozturk and Acaravci, 2010).

In 2015, MDBs established more than US$25bn to climate financing, funding more than US$131bn total in climate work since 2011. MDBs have implemented many common methodologies for developing the climate budget finance, enhancing transparency to achieve a global financial development flow (WDI, 1990/2016).

In the same year, common principles were developed in regard to mitigation and adaptation activities through the International Finance Club for Development (IFC), which involved establishing a set of guidelines for co-financing climate flow in which more than US$55bn dollars was invested (WDI, 1990/2016).

Some of the most important roles of MDBs include reducing the costs and risks associated with climate financing investments and building the institutional capacity of operations (Nguyen and Amin, 2002). The resources of MDBs manage only part of the global climate finance landscape, contributing only fractionally to low-carbon initiatives and flexible infrastructure (Dogan and Turkekul, 2016).

MDBs continue to work with public sources to provide risk-sharing measures specifically designed to stimulate private financing (Nguyen and Amin, 2002). In addition, they also strengthen the capacities of their client countries to enable the establishment of specific climate change projects and provide effective access to resources (Acharyya, 2009). Climate model funding studies are still scarce; however, Soytas and Sari (2009) suggest that the global carbon tax is the most important element for countries to fund.

The impact of financial development is still unclear. There are a variety of existing arguments regarding his predictions and explanations of its possible effects. One school of thought suggests that financial development leads to an increase in energy consumption by increasing economic growth (Sadorsky, 2010; Shahbaz and Lean, 2012). A high degree of financial development leads to higher economic growth, which requires more energy consumption. However, a second school of thought believes that financial development helps reduce CO_2 emissions through the energy efficiency effect. Financial development aids listed companies in enhancing energy efficiency, significantly cutting carbon emissions. Also, certain financial services, such as green bonds, are considered environmentally friendly.

There is a third-party belief that financial development has a non-linear relationship with energy consumption. In previous literature, such as Mahalik *et al.* (2017) argued that energy demand rises as the development of the financial sector increases (i.e. credit allocation to firms). After a threshold level of financial development is reached, the financial sector encourages adopting an energy-efficient technology for their businesses, which as a result reduces the intensity of energy use. This explains the relationship between financial development and energy consumption is an inverted U-shape. Therefore, it can be hypothesized that financial development has a concave relationship with energy consumption.

The study's contribution includes questioning burden sharing, whether it will have an impact on global climate change and how all countries will receive these policies. The study also addresses the research gap that links economic, foreign financial and environmental variables to assess growth in a clean environment, despite technological developments and heavy industries that create environmental emissions that affect the welfare of society.

This study aims to development policies regarding finance climate change. Additionally, it contributes to the enhancement of current knowledge regarding this factor. It is the first study to diagnose a country's foreign, financial and economic growth in regard to CO_2 emissions within a sample of 32 selected Organization for Economic Co-operation and Development (OECD) countries. In the course of the study, several panel data methods, such as the GMM and IV-FE approaches, were performed.

This study gives enhanced understanding of the hypotheses, Figures 1 and 2 show the possible correlation between foreign finance measurements and CO_2 emissions. A careful observation of these correlations shows that the foreign finance–environmental quality relationship in OECD economies is driven by non-linear relationships. In other words, foreign finance increases pollution at the first stage, and it then helps reduce CO_2 generating the inverted U-shape association. These figures help investigate the possible non-linear relationship between foreign finance and pollution in OECD countries.

This study found that foreign finance and environmental quality have a concave relationship. Furthermore, the foreign investments of three proxies, foreign assets and remittance in the first stages contribute significantly to CO_2 emissions; however, after the threshold point was reached, these proxies became "environmentally friendly" via their contribution to reducing CO_2 emissions. Also, this paper found that there is a non-linear relationship illustrating that foreign investment (as a proxy of foreign finance) in OECD countries enhances the importance of environmental quality because it more significantly improves the environmental quality than foreign assets. Additionally, empirical results show that remittances received variable is the most polluted until a certain level, upon which it then helps reduce CO_2 emissions. This study also found that there is an N-shaped

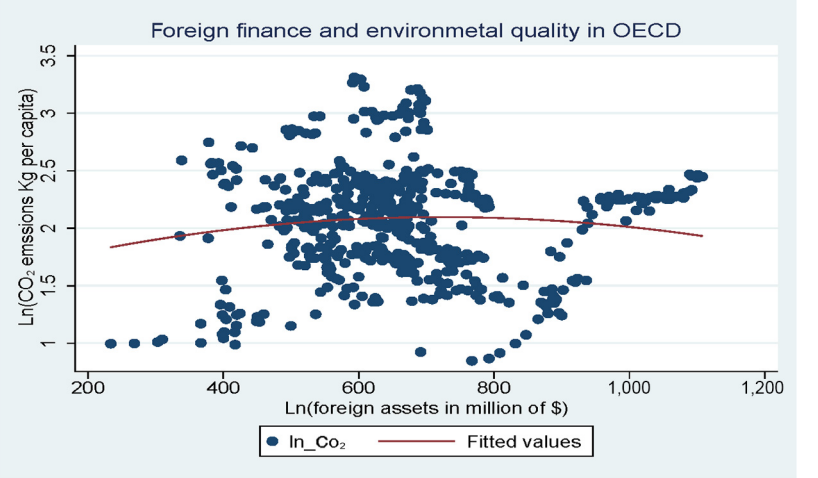

Figure 1.
Plots of foreign assets and CO_2 emissions relationship

Source: (STATA.15 output)

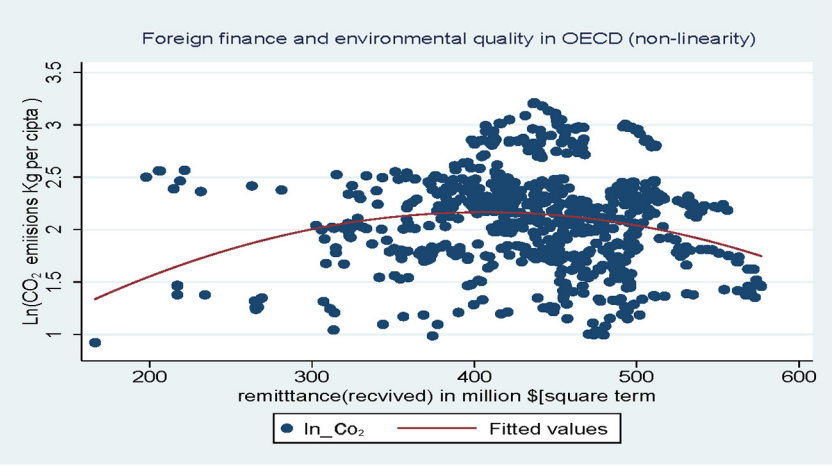

Figure 2.
Plots of remittance and CO_2 emissions relationship

Source: (STATA.15 output)

relationship that explains that economic growth produces more CO_2 emissions at the first stage of economic growth than beyond the first threshold level, economic growth improves the quality of environment. After that, there is a second threshold level; this economic growth makes the environment deteriorate. Overall, the results of this study were robust even after controlling for the omitted variable.

The structure of this paper, following the introduction, is organized as follows: Section 2 reviews foreign finance, economic growth and CO_2 by explaining the environmental Kuznets curve (EKC) theory and then presents previous studies. Section 3 discusses the methodology, data and equations used, while Section 4 presents the empirical results and discussion. Finally, Section 5 provides the conclusions and policy implications.

2. Foreign finance, economic growth and CO_2: a literature review

This section reviews previous papers on the relationship between economic growth, foreign direct investment (FDI) and CO_2 emissions. For clarity, this literature review is comprised of two segments relating to two different categories within the literature: the economic growth-CO_2 emissions nexus and the nexus between FDI and CO_2 emissions. The following sections discuss both nexus by drawing on existing and relevant evidence.

2.1 Economic growth-CO_2 emissions relationship

Global warming in regard to climate change has become an important issue, as CO_2 is one of the leading concerns of most countries (Fernandes and Paunov, 2012). This issue has only grown significantly in recent years due to human-produced activities involving oil, gas and other chemicals, which are the main energy and electricity resources in various industrial, service and transport sectors and are directly related to growth (Galeotti *et al.*, 2009). Therefore, the EKC developed by Kuznets (1955) highlights the inequality of income relationship, which assumes that countries begin to develop economic inequality that increases to a certain degree, and after that, the disparity begins to decline after reaching average income represented by an inverted U-shape.

Since the pioneering work of Grossman and Krueger (1955), the EKC has attracted significant attention and garnered several empirical applications. The EKC hypothesis suggests that economic growth at an initial stage requires a high demand for raw materials and natural resources, which leads to more CO_2 emissions and harmful waste. Therefore, in the early phase of economic development, pollution and economic growth grow parallel. After a certain amount of time, modern techniques and technology are introduced in developed economies; consequently, industrial waste begins to diminish, mitigating environmental decay.

Salahuddin *et al.* (2018) noted that improving economic growth causes environmental problems because increased production levels increase environmental pollution. However, Acharyya (2009) mentions that a hypothesis regarding economic development and environmental issues is more complex. On the other hand, Hao and Liu (2015) argue that economic growth can improve environmental output through countries' continued clean production. Overall, these theories confirm that it is essential to understand the dynamic environment and what its effect is on the economic situation and environmental degradation (Ozturk and Acaravci, 2010).

The EKC theory plays a vital role in several environmental pollutants, but the most important source regarding this concept was developed by Lau *et al.* (2014) in reference to CO_2. Carbon dioxide (CO_2) is considered a major source of environmental issues and comprises the largest portion of GHGs. Many previous studies explain the financial and economic activities that affect CO_2 and confirm CO_2's effect on pollution from a global perspective (Koçak and Şarkgüneşi, 2018).

The model is formulated as a U-shaped relationship between variables of economic growth or foreign financial indicators and pollution measured by CO_2 emissions.This model is a dynamic process of change regarding the growth and increased income of an economy over time as the level of CO_2 emissions, at the first step, reaches its peak before beginning to decline and reaching the point of income required (Sadorsky, 2010). The relationship begins with the link between economic growth and increase in CO_2 emissions, and then, these emissions become exhausted when the economy reaches the stage of economic growth (Pao and Tsai, 2010).

The EKC model represents structural changes in the environmental economy with economic growth (Lau *et al.*, 2014). Economic growth can be linked to continuous structural transformations in different industrial sectors of society and is based on the content of change, which varies from one period to the next depending on the economy over time. The most common stage is the transfer of growth from agriculture to industry, which is then followed by a spread of these systems into industrial services (Ren *et al.*, 2014). Environmental degradation becomes concentrated due to the noticeable change in the economic structure resulting from the transformation of production elements from rural to urban areas and from the agricultural sector to industries that are based on intensive production and consumption. This occurs after a certain point of decline, which is a result of the entry of technology and heavy industries that contribute positively to the development of economic and financial sectors of society (Dogan and Turkekul, 2016).

The increased use of natural resources causes increased pollutant emissions, with a phase of economic development beginning to evolve (Pao and Tsai, 2010). When countries begin to increase their industrial activity, it becomes increasingly important to educate individuals about the environment, which can lead to higher environmental spending, increased technology efficiency and an increased demand for an efficient environment (Ren *et al.*, 2014).

When the income of individuals increases, heavy industrial production becomes phased out in favor of more technologically advanced and service-intensive production. This development is a positive obstacle to the increase of pollution (Zhang and Zhou, 2016). The effects of a high-tech and productive economy contribute to low pollution, high demand for a clean climate, increased political concern and increased levels of prosperity in the community (Galeotti *et al.*, 2009). Moreover, any increase in pollution levels is due to increased production, which requires increased production inputs and an increased use of natural resources (Alfaro *et al.*, 2004).

Technology is an important factor in economic growth if it is used effectively to benefit the environment. The basic economic theory explains that countries should work at a competitive advanatageto achieve a low price for products by investing in both effective technology and developing economic and financial sectors, which will ultimately affect the environment and pollution levels (Zhang and Zhou, 2016). This occurs when the heavy industry in economy moves toward a more intensive economy, which can be explained by the increased need for research and development that increases the per capita GDP without increasing the levels of pollution (Koçak and Şarkgüneşi, 2018).

Hao and Liu (2015) and Alfaro *et al.* (2004) argue that dirty production (manufacturing industry) is represented in developing countries with high levels of pollution, while green production is represented in developed countries with low levels of pollution and results in international trade.

2.2 Foreign finance-CO_2 emissions relationship

Foreign economies assessing energy levels through foreign capital inflow is necessary to help emerging countries finance clean energy projects (Paramati *et al.*, 2017). This view is based on external factors such as the capital flow, transfer of technology and economic knowledge that leads to the reduction of CO_2 emissions.

The global development of financial markets increases the consistency of information on the deployment of renewable energy via external financing (Lee, 2013). Alfaro *et al.* (2004) stated that the quality of the environment enhances a country's financial development. It is essential that foreign energies contribute to the flow of foreign capital, as this will promote sustainable development, create clean energy and reduce environmental degradation.

Much of the previous literature is related to the current study in one or more ways. For example, financing climate is one component of green financing, which is funded through governments. This refers to the transfer of financial flow to projects regarding the environment and society by reducing the percentage of pollution.

Sectors such as banking, insurance and investing stimulate business in society. Countries are also working to adopt a green financing policy by avoiding certain project risks to ensure that the implementation of these projects will not harm the environment. Lee (2009) argued that the interaction of FDI activities can cause carbon emissions. Furthermore, Pao and Tsai (2011) showed BRIC countries that are FDI can also cause carbon emissions. Lau *et al.* (2014) found that the co-integration of FDI variables can increase CO_2 emissions, while Ren *et al.* (2014) applied the generalized method of moment (GMM) estimation and found that FDI leads the industry sector with CO_2 emissions.

Görg and Strobl (2005) explained that foreign investment is affected by the flow of technology in all countries. However, the countries that benefit from technology in a positive manner reflected on the positive environment regarding the ecosystems and macroeconomic nature of these countries. Eskeland and Harrison (2003) argued that multinational companies in emerging countries do not tend to pollute the environment, while Dasgupta *et al.* (2000) explained that environmental compliance in emerging countries is important for

analyzing environmental impact and policy-making. The results indicated that environmental management has a significant impact on compliance rules. Cole *et al.* (2008) indicated that foreign training benefits the environment by reducing the use of fuel (especially in foreign companies) and environmental pollution. Albornoz *et al.* (2009) indicated that foreign companies implement environmental regulations and operate under formal and informal channels. Moreover, Doytch and Uctum (2016) found that the type of investment inflow affects the industrial and non-financial sectors and may be negatively impacted. Overall, the unequal distribution of income in developing countries can harm the environment.

Akbostanci *et al.* (2009) indicated that there is a long-term relationship between income increase and environmental activities, which ensures that when income rises, it will affect production and cause a certain percentage of pollution, while Galeotti *et al.* (2009) argued that the EKC model does not always provide indicators of CO_2 in society. In another study by Maddison and Rehdanz (2008), a strong, causal relationship between GDP per capita and environment was found. Behera and Dash (2017) applied fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) estimators to show that there is a positive effect of the FDI on CO_2 emissions.

Similarly, Koçak and Şarkgüneşi (2018) explained that technology may contribute to energy saving during productive activities and thus contribute to a positive relationship between foreign investment and the environment. For instance, Hao and Liu (2015) argued that FDI reduces CO_2 emissions through the application of the GMM procedure. Similarly, Zhang and Zhou (2016) proposed that reducing CO_2 emissions with FDI conserves energy via the adoption of an energy-efficient technology.

Nguyen and Amin (2002) analyzed foreign investment demand for energy and a clean environment and found a positive relationship between these factors, which promotes consumer energy and stimulates production in a country. In another study by Mielnik and Goldemberg (2002), there was evidence that FDI increases CO_2 emissions. In a recent study by Salahuddin *et al.* (2018), it was found that foreign activities increase CO_2 emissions.

Lee (2009) suggested an adverse effect between economic growth and the activities of energy consumption, which varies according to the financial economic development of countries in both the short and long term. Behera and Dash (2017) highlighted the fact that there is a strong correlation between economic growth and foreign investment in most developed and emerging countries. Furthermore, Hao and Liu (2015) found that there is a long- and short-term impact of foreign investments on the outputs of economic development. Sadorsky (2010) found that foreign investment is significantly correlated with demand for energy in more than 22 emerging countries, arguing that the obtainment of large loans will cause an increase in CO_2 emissions by developing the infrastructure of financial development.

Ren *et al.* (2014) explained that countries in industrial zones encourage many foreign investors to begin investing, and because there is still little knowledge on how to use resources more efficiently, an increase CO_2 will occur. On the other hand, Shahbaz *et al.* (2013) focused on the private sector and found that financial development does not have a large effect on CO_2 emissions.

This shows that several studies have examined the relationship between FDI or financial development on environmental degradation, but few studies have examined the impact of foreign finance (i.e. FDI), remittances and foreign assets as three indicators of CO_2 emission levels to conserve clean energy and achieve a sustainable environment.

3. Methodology

3.1 Empirical model and data

This empirical paper aimed to examine the association between foreign finance and economic growth on CO_2 emissions in selected OECD economies. To achieve this aim, this paper applied panel data techniques. The panel set contained 32 out of 36 OECD countries, exempting four countries: New Zealand, Poland, the Slovak Republic and Slovenia. The study examined these countries from 1990 to 2015 and ensured the obtainment of 27 observations for each country. The proposed model for this study was based on the theoretical framework developed by Doytch and Uctum (2016):

$$CO_2 = \left(FF_{i,t}, FF^2_{i,t}, GDP_{i,t}, GDP^2_{i,t}, GDP^3_{i,t}\right) \tag{1}$$

Where CO_2 is carbon dioxide emission per capita, FF is various foreign finance proxies for country i in time t and GDP is gross domestic product per capita as a proxy for economic growth. All variables were measured by a natural logarithm to attain reliable results. Also, this logarithm form helped interpret the coefficients, as all coefficients could be expressed as elasticities, which provided a clear interpretation of the results. Therefore, the proposed model was:

$$\begin{aligned} \text{In\_}CO_2 \;=\; & \beta 0 + \beta 1 \text{In\_}FF_{i,t} + \beta 2 \text{In\_}FF^2_{i,t} + \beta 3 \text{In\_}GDP_{i,t} + \beta 4 \text{In\_}GDP^2_{i,t} \\ & + \beta 5 \text{In\_}GDP^3_{i,t} + \upsilon_i + \text{e}_{i,t} \end{aligned} \tag{2}$$

where betas are estimated as parameters based on their signs. There were two main hypotheses that were the focus of this study: EKC foreign finance (FF)-CO_2 emissions and EKC economic growth-CO_2 emissions.

The EKC can take several shapes according to parameters related to income (Alvare *et al.* (2016, 2018).

- $\beta 3 > 0$ and $\beta 4 = \beta 5 = 0$; in this situation, the relationship is monotonic, increasing as environmental degradation rises along with economic growth;
- $\beta 3 < 0$ and $\beta 4 = \beta 5 = 0$; this means that there is a monotonic negative association between environmental degradation and economic growth;
- $\beta 3 > 0$, $\beta 4 < 0$ and $\beta 5 = 0$; this gives the traditional, inverse U-shaped EKC;
- $\beta 3 < 0$, $\beta 4 > 0$ and $\beta 5 = 0$; this indicates a U-shaped relationship; and
- If $\beta 3 < 0$, $\beta 4 > 0$ and $\beta 5$; this case shows an inverse N-shaped relationship between environmental degradation and income.

In regard to financial development, the inverted U-shape between foreign financial development and environmental quality is present when $\beta 1 > 0$ and $\beta 2 < 0$ (Shahbaz *et al.*, 2013).

This study used a variety of different proxies as foreign financial indicators to increase the robustness of the results. Following the previous studies, FDI (Acharyya, 2009; Lau *et al.*, 2014; Blanco *et al.*, 2013), forging assets (Shahbaz *et al.*, 2018), remittances (Akçay and Demirtaş, 2015) were used in this study. Economic growth measured by real GDP per capita was constant at 2010 prices. The definitions of variables and the data sources are reported in Table I. All variables were extracted from the World Bank (World Development Indicators,

Table I.
FF, economic growth and CO_2 emissions: FE model

Dependent variables: Ln(CO_2 per capita) Independent variables	(1) FDI	(2) Foreign assets	(3) Remittance paid	(4) Remittance received
Ln (GDP per capita)	47.65*** (8.135)	−1.847 (6.579)	21.39*** (6.231)	39.30*** (5.666)
Ln (GDP per capita^2)	−4.781*** (0.822)	0.301 (0.660)	−2.120*** (0.628)	−3.906*** (0.571)
Ln (GDP per capita^3)	0.159*** (0.0276)	−0.0139 (0.0220)	0.0700*** (0.0210)	0.129*** (0.0191)
Ln (FDI)	*0.109*** (0.0476)			
FDI^2	*−0.00222*** (0.00109)			
Ln (foreign assets)		*0.0726*** (0.0369)		
Ln (foreign assets^2)		*−0.00149** (0.000784)		
Ln (remittance(paid))			*0.130**** (0.0382)	
Ln (remittance(paid)^2)			*−0.00387**** (0.00104)	
Ln (remittance(received))				*0.366**** (0.0432)
Ln (remittance(received)^2)				*−0.00993**** (0.00111)
Constant	−155.9*** (26.75)	3.495 (21.73)	−70.73*** (20.56)	−132.6*** (18.68)
Observations	336	528	712	738
R^2	0.151	0.063	0.045	0.174
Number of ID	26	31	32	32
Country fixed	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Hausman test for Fixed Effects	6.78 (0.07)	3.01 (0.039)	7.38 (0.06)	2.63 (0.0451)
F-test	10.87 (0.00)	6.65 (0.00)	6.35 (0.00)	29.53 (0.00)

Notes: STATA version 15 output; standard errors in parentheses *at $p < 0.10$; **at $p < 0.05$; ***at $p < 0.01$

1990/2016). Not all data were available for all countries after 2015, so the study period was limited from 1990 to 2015, which is considered a limitation of this study.

3.2 Estimation strategies

This paper began estimations of our model by applying a panel OLS estimator (fixed-effects (FE) and random-effects (RE) models). These methods are commonly used in panel data analysis. The fixed effects model is appropriate due to its ability to control for unobserved country effects (i.e. heterogeneity issues). To choose whether the FE or RE model was most appropriate, a Hausman test was conducted for the FE model. The null hypothesis of this test was that the RE model is more efficient. Overall, the FE model was preferable because it controls for unobserved country-specific effects and mitigates the problem of multicollinearity.

However, panel OLS estimators can suffer from an endogeneity problem due to correlations between the dependent variable(s) and the error term. Therefore, the GMM approach was applied to overcome this issue, a method proposed by Arellano and Bond (1991) and developed by Roodman (2009). To test the robustness of the results; this study also applied the instrumental variables (IV) – FE estimator.

4. Results and discussions

4.1 Empirical results: fixed-effects model

This section empirically attempts to test the hypotheses regarding the U-shape relationship between FF and pollution and the N-shape growth-pollution thesis.

4.1.1 The foreign finance-CO_2 emissions association: the inverted U-shape relationship hypothesis. Beginning with *H1*, which was related to the FF–pollution relationship, Table I reports the findings on 32 OECD countries based on the FE model estimator. Column 1 of this table shows the estimates for the first proxy of FF, which is a net, FDI inflow. The result indicates an inverted U- shaped association between net FDI and CO_2 emissions, which means that foreign investment in the first stages contributes significantly to CO_2 emissions, but, after reaching the threshold point, these investments become more "environmentally friendly" via their contribution to reducing CO_2 emissions.

These empirical findings are consistent with Nguyen and Amin (2002) who showed that foreign capital creates additional funds to promote technology development and support the environment. Conversely, Salahuddin *et al.* (2018) found that there is no significant statistical relationship between financial development and clean energy use, as the nature of investments is not clean and technology is not used in applications that provide advantages for reducing costs. The financial technology used did not adequately reflect the development of the financial system.

In Table I, Column 2, the model was re-estimated by using the second proxy of foreign financial development, which refers to foreign assets. The inverted U-shape hypothesis is confirmed again. It should be noted that foreign assets contribute less to CO_2 emission levels in OECD (coefficient 0.07) compared with FDI (0.109) based on the linear relationship. While the non-linearity denotes that foreign investment in OECD countries enhances the importance of environmental quality over foreign assets (seethe FDI-squared term coefficient in the results). Similarly, Zhang and Zhou (2016) mentioned that CO_2 emission can be improved through FDI inflow, which induces clean energy consumption.

Additionally, FF was proxies using remittance variables, personal remittances received and personal remittances paid. These two variables comprise the personal transfers and compensation of an employee. The findings in Table I Columns 3 and 4 show that remittances (paid and received) have an inverse U-shaped association with pollution, while

the findings also show that remittances received are the most polluted FF in OECD countries until a certain level, at which point it then helps reduce CO_2 emission. These results once again validate the inverted U-shaped association, indicating that foreign remittances received are used to improve clean energy use and thus work to develop the financial system. Lee (2009) confirmed this result by alluding to the causal relationship related to clean energy consumption.

The concave relationship between finance and energy consumption can be explained by the fact that, initially, energy demand rises because of financial development sector increase, but after a threshold level of financial development is reached, the financial sector encourages adopting energy-efficient technology for their businesses, which as a result reduces the intensity of energy use. This indicates that the relationship between financial development and energy consumption is an inverted U-shape (Mahalik *et al.*, 2017). This is significantly true in regard to FDI and financial assets.

This is because remittance boosts energy consumption. Increasing migrant remittances improves the standard of living of the recipient households and increases their income, thus increasing the demand for energy. This indirect effect of external financing may increase productive investments, which can be defined as investments that improve household income in the future in ways that are generated by non-remittance (Akçay and Demirtaş, 2015). Because of this significant impact, governments of different countries impose certain regulations in different industries to mitigate energy consumption.

4.1.2 Economic growth-CO_2 emissions association: the N-shape relationship hypothesis. Next, the validity of the N-shaped relationship between CO_2 emissions and economic growth was examined. In Table I, it can be seen that pollution increases when economic growth increases up to a certain point, at which point CO_2 emissions then decreased. Again, the greater of economic activities, the greater will be the increase in pollution in OECD economies. This indicates that economic growth begins first with improving the quality of the environment and has a positive relationship until it reaches a certain level of income, with the relationship becoming negative once more, which canpotentially be explained by the increase in energy efficiency.

The increase in CO_2 can be explained by the active activities of foreign investments operating in these countries, allowing technology to flow to less prosperous countries. Thus, technological developments may exceed the industrial activities in society, leading to the pollution of the local environment due to a heavy industry or a negative impact of GDP on CO_2. The N-shape can be interpreted through low per capita income initially, leading to an initial increase in pollution but then an eventual decrease over time with a per capita income increase. At some point, however, income emissions may begin to rise again.

4.2 Generalized method of moments and instrumental variable estimations

One potential concern could involve the preferred FF variables that are endogenous and the expected reverse causality between these proxies and CO_2 emissions. Therefore, this issue was mitigated by applying the common estimator, which is the GMM that uses IVs (IV-FE) estimators to ensure robustness. The GMM and IV-FE results are reported in Table II. These results provide robust evidence regarding the inverse U-shaped relationship between FF proxies and the environmental quality measure based on CO_2 emissions per capita. Also, these results provide significant evidence regarding the N-shape of economic growth and pollution.

4.2.1 The foreign finance-CO_2 emissions association: the inverted U-shape relationship hypothesis. In recent years, foreign investments and assets have been considered an important economic driving force behind many countries, with energy flow, economic

Table II.
FF, economic growth and CO_2 emissions: GMM and IV-FE result

Dependent variable: Ln (CO_2 per capita)	(1) IV (FDI)	(2) GMM (FDI)	(3) IV (foreign assets)	(4) GMM (foreign assets)	(5) IV remittance (paid)	(6) GMM remittance (paid)	(7) IV remittance (received)	(8) GMM remittance (received)
Ln(FDI)	*0.163***(0.0650)	*0.0673* (0.0530)						
Ln(FDI^2)	*−0.00331*** (0.00144)	*−0.00125* (0.00124)						
Ln(GDP per capita)	39.12*** (8.066)	10.94 (15.73)	1.452 (7.033)	−13.64 (20.29)	22.82*** (6.491)	27.38 (20.05)	44.89*** (6.075)	45.30*** (15.43)
Ln (GDP per capita^2)	−3.881*** (0.818)	−0.908 (1.598)	−0.0362 (0.707)	1.433 (2.039)	−2.273*** (0.655)	−2.807 (2.025)	−4.466*** (0.613)	−4.549*** (1.567)
Ln (GDP per capita^3)	0.127*** (0.0275)	0.0238 (0.0540)	−0.00246 (0.0236)	−0.0495 (0.0680)	0.0754*** (0.0220)	0.0961 (0.0679)	0.148*** (0.0205)	0.152*** (0.0529)
Ln (foreign assets)			*0.0963*** (0.0452)	*−0.0450* (0.143)				
Ln (foreign assets^2)			*−0.00192*** (0.000952)	*0.000669* (0.00294)				
Ln (remittance (paid))					*0.168**** (0.0399)	*0.411*** (0.178)		
Ln (remittance (paid)^2)					*−0.00490**** (0.00108)	*−0.0121*** (0.00490)		
Ln (remittance (received))							*0.328**** (0.0480)	*0.337*** (0.141)
Ln (remittance (received) ^{2})							*−0.00893**** (0.00122)	*−0.0107**** (0.00389)
Constant	−130.0*** (26.39)		−7.500 (23.22)		−75.56*** (21.38)		−150.7*** (20.01)	
Observations	243	190	475	422	684	651	708	675
Number of ID	23	20	31	31	32	31	32	32
R^2	0.17		0.05		0.0556		0.1644	
AR (1))		−0.71 (0.49)		−0.76 (0.445)		−1.21 (0.225)		−1.48 (0.140)
AR (2)		−0.17 (0.86)		−0.88 (0.376)		−0.14 (0.885)		−0.831 (0.408)
Hansen test		15.13 (1.00)		24.57 (1.00)		30.09 (1.00)		30.90 (1.00)
Wald test	178.7 (0.000)		162.4 (0.000)		267.1 (0.000)		326.4 (0.000)	

Notes: STATA version 15 output; standard errors in parentheses *at $p < 0.10$; **at $p < 0.05$; ***at $p < 0.01$

growth and environmental pollution having also been cited. Some studies have tested the causal relationship between foreign assets and the quality of the environment. Sadorsky (2010) explained that most CO_2 emissions were found to be due to heavy industries, while Blanco *et al.* (2013) argued that the best investment options lie in developing countries due to the decline in strict environmental policies.

Mielnik and Goldemberg (2002) pointed out that foreign investment is not a source of pollution because it uses advanced technology within a sophisticated infrastructure. Furthermore, it is evident in Table II that foreign investments contribute significantly to pollution when they increase by 10 per cent, with approximately 11 per cent on average (GMM coefficient 0.163 + IV coefficients 0.067/2); however, investment after a certain level (turning point) helps promote green investments, which can consequently help reduce CO_2 emissions.

Also, the results confirm that remittances are the most important factor in regard to CO_2 emissions. The coefficient of remittances was 0.33 and 0.34. This refers to the fact that CO_2 emissions increase by 3.3 and 8.4 per cent when remittances rise by 10 per cent.

4.2.2 The economic growth-CO_2 emissions association: the N-shape relationship hypothesis. Again, the results regarding CO_2 emissions and economic growth confirm the N-shape relationship. The findings also prove the existence of the N-shaped relationship between GDP per capita and environmental degradation. Examining the results of the OLS estimation in Table II, it is evident that economic growth produces higher CO_2 emission levels at the beginning of economic growth, but the quadratic term confirms this effect becomes negative after a certain level of GDP is reached. Then, this economic growth causes the environment to deteriorate. Thus, the result is robust even after controlling for the omitted variable issue. Overall, the IV-FE results indicate an N-shaped relationship in the OECD countries.

This result is consistent with findings by Shahbaz *et al.* (2013), who argued for the inverted N-shape, and Lee (2009), who argued other economic factors influence economic growth and contribute to an increased demand for clean consumption practices. Other studies, such as those of Soytas and Sari (2009) and Chandran and Tang (2013), show that clean consumption reduces CO_2 emissions in the in ASEAN-5 economies. These results are consistent with the policy effects on most countries regarding the creation of foreign assets. Additionally, Pao and Tsai (2010) explained that economic growth levels and activities of energy consumption have an effect on environmental degradation in most countries, while Akbostanci *et al.* (2009) tested the EKC theory and found a long-term relationship between CO_2 and income.

National policies and the international investment structure attract investments through OECD countries for economic growth. Addressing the challenges of host countries in regard to building a broad, transparent base to enable the political environment of investment and institutional building, OECD countries contribute to development by facilitatinga way for developing countries to access technology and benefit from public projects and encouraging non-OECD member countries to adhere to international frameworks based on investment rules.One of the potential disadvantages of OECD countries is the deterioration of the balance between payment and profits, as foreign investment works to compensate revenues. Therefore, OECD countries should improve the domestic investment environment where the adverse environment can impact investment turmoil due to the presence of heavy, extractive industries accelerating in the least developed countries. Competition in national markets is affected by foreign investment; therefore, the host economy is often unable to benefit from technology or the knowledge transferred through foreign investment.

Policies play an important role in establishing FDI that will be influenced by many facors, such as the expected profitability of individual projects and the ease of handling subsidiaries and the strategies on which the foreign investment and comprehensive quality of the environment of the host country are based. However, there are some factors that determine expected profitability based on the size of the local market and geographical location.

The OECD has a primary responsibility to act as headquarters for sharing member experiences regarding tools used for cooperation in foreign investment through long-term investment policy references and recommendations from governments with different views.

The success of such an approach depends on the mechanisms for coordinating the use of resources for capacity-enhancing and technical assistance. Moreover, the assistance of a country does not only depend on another singular country but rather on collective, international determination to build an inter-related investment capacity. CO_2 emission levels is one of the contemporary issues of concern for OECD countries; climate change can have significant social consequences that affect human well-being and increase the risk of sudden changes in climate and ecosystems. Approximately 70 per cent of the CO_2 emissions stem from the energy extracted due to an increase in global energy demand, and emissions are expected to increase due to an increased demand for cars, especially in developing countries. Historically, OECD countries are responsible for increasing emissions, and economic growth is one of the main reasons for this increase. Technological advances and structural transformations are expected to improve energy usage in the countries. OECD countries have also made progress in the development of national climate adaptation strategies and have been encouraging the assessment and management of climate risks in relevant sectors. Increased private sector involvement is also essential in regard to the integration of climate change adaptation in development cooperation. The increase in real GDP growth rate, low inflation rates, low unemployment rates and improved external account growth are four major objectives of not only OECD countries but all countries in the world in regard to the creation of economic policies.

4.3 Diagnostic tests

This section reports and discusses the findings in Tables I and II by testing certain widely used diagnostic tests to check whether or not the results are consistent and unbiased. We perform the Hausman test to select the appropriate model for FE and RE. The results showed that the Hausman test strongly rejected the null hypothesis regarding the RE model being appropriate (Table I).

Additionally, focus was placed on the Sargan test statistics, which examine the correlation between IVs and endogenous variables (Arellano and Bond, 1991).

The GMM results confirm that the instruments are exogenous and not over-identified. The null hypothesis regarding this fact is therefore rejected in Table II (Hansen test statstics). Another important test was the Arellano and Bond test for autocorrelation. This test checks for autocorrelation among residuals. Based on Arellano and Bond autocorrelation AR (1) and AR (2) statistics, the null hypothesis was rejected.

5. Conclusion and policy implication

Environmental degradation plays a vital role in challenges faced by the economies of several countries. The consequences of the heavy pollution that has persisted for several years have been influential in short- and long-term perspectives as well as at local and global levels. From a local perspective, pollution affects local ecosystems directly, and thus, when ecosystem dynamics are changed, the balance of living organisms disintegrates and affects

all parts of the society. This situation can affect a country's economic and financial systems, as the environmental system affects the ability to attract investments and assets, foreign remittances and all foreign financial work, in the sense that the degree of control affected by the level of environmental situation available.

Economic growth and FF have become important factors and are dominated by environment, in which it has been noted that increasing production and foreign investment correlated with increasing pollution in the environment. Some hypotheses have found that the association between economic and FF indicators with environmental degradation is difficult to explain. There are also several assumptions regarding the fact that economic and financial growth improves the environment, and therefore, it is important to understand this interconnected relationship between the environment and economic system.

This study aimed to examine the relationship between FF, economic growth and CO_2 emissions to investigate if the EKC exists as empirical evidence among the 32 selected OECD countries. This study used quantitative tests for the hypotheses and applied panel data techniques. The panel set contained 32 countries during the period from 1990 to 2015 and ensured 27 observations for each country. This study applied a panel OLS estimator through an FE model and solved the endogeneity issue using the GMM, IV-FE estimators and diagnostic tests. The empirical findings provide two interesting results: the FF–environmental degradation relationship is shaped like an inverted U and the relationship between economic growth and CO_2 emissions is N-shaped.

For FF–CO2 emission, the inverse U-shaped association is consistent with the finding of Shahbaz *et al.* (2013). There are two possible explanations behind this behavior: first, it is related to the transition from the manufacturing industry (i.e. the dirty sector) to the service sector. This process increases CO_2 emissions at the initial stage, but then helps to reduce pollution (Shahbaz *et al.*, 2013). Also, OECD governments provide loans and financial aid to green projects.

The second is related to environmental regulations. The OECD countries impose strict rules on multinational firms. At the first stage, they locate operations to save environmental costs, which usually are industries are pollution-intensive industries (i.e. pollution havens) (Blanco *et al.*, 2013), but due to environmental constraints, multinational firms face environmental regulation, especially in OECD countries. This then leads to the improvement of efficient energy use (Mielnik and Goldemberg, 2002).

For the economic growth–CO_2 emissions relationship, the results are in line with the findings of Churchill *et al.* (2018) and Allard *et al.* (2018). The curve was initially an inverted U-shape, but after a certain point, emissions once again rose and the relationship became U-shaped.

The results of this study analyze the methods used by economic and financial decision-makers in each country by describing the strengths and weaknesses of their performances in the financial and social economy and their design of economic policy that helps attract investments and increase economic growth. This study supports the policies of OECD countries for creating economic and financial conditions conducive to environmental systems. Furthermore, it calls for the adoption of green environmental practices, which require the continuous consideration of the created policies.This study calls for further research to search for analytical economic and financial models explaining the beahaviour of economic system to ensure the establishment of economic policies that are compatible with the environment, social effects and economic and financial growth through their application in a wideselection of ideologically different countries. The study recommends that future research is needed to consider social and political variables that can add value to FF and economic grwoth and impact the environment situation.

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Further reading

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Appendix 1

Variable	Definition	Source
CO_2 emissions (metric tons per capita)	CO_2 emissions are generated by the burning of fossil fuels, the consumption of solid fuels, liquids and gas and the activities of the cement industry	World Development Indicators
FDI, net inflows (constant US$)	FDI refers to cash flows or investment stocks that flow into the state, contribute to the building of the state's economy and achieve a degree of control over economic growth	World Development Indicators
Net foreign assets (constant US$)	Foreign assets represent foreign liabilities, which are invested in the country from external sources and are held by the government's monetary authorities	World Development Indicators
Personal remittances paid (constant US$)	Including all current transfers made in cash or in kind made or received by family's resident in the state or to non-resident households	World Development Indicators
Personal remittances received (constant US $)	Including all current transfers made in cash or in kind by or received by family's resident in the state or to non-resident families	World Development Indicators
GDP per capita	GDP per capita is the gross domestic product (GDP) divided by mid-year population. GDP represents the total value added of all producers residing in the country's economy as well as any product taxes minus any subsidies not included in the value of the product	World Development Indicators

Table AI.
Variable definitions and sources

Appendix 2. Sample (32 countries)

Included: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the UK and the USA.

Excluded: New Zealand, Poland, the Slovak Republic and Slovenia.

Appendix 3

Variable	Observations	Mean	SD	Minimum	Maximum
CO_2 emissions per capita	793	9.066	4.463	2.328	27.431
FDI net inflows	795	5.89e + 09	3.47e + 10	−2.58e + 11	2.11e + 11
Foreign assets	815	6.92e + 12	3.45e + 13	−3.05e + 13	3.99e + 14
GDP per capita (constant 2010)	848	35680.52	20920.29	5132.953	112000
Remittance paid	789	4.41e + 09	8.32e + 09	181000	6.32e + 10
Remittance Received	812	2.98e + 09	4.46e + 09	400000	2.87e + 10

Source: STATA version 15 output

Table AII. Descriptive statistics

Appendix 4

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) CO_2 per capita	1.000											
(2) FDI	0.088	1.000										
(3) foreign asset	0.041	0.115	1.000									
(4) GDP capita	0.385	0.060	−0.200	1.000								
(5) remittance paid	0.389	0.280	0.043	0.214	1.000							
(6) remittance received	−0.167	0.074	0.079	−0.143	0.349	1.000						
(7) GDP^2	0.337	0.079	−0.222	0.941	0.217	−0.152	1.000					
(8) GDP^3	0.343	0.077	−0.223	0.952	0.218	−0.151	0.999	1.000				
(9) FDI^2	0.201	0.716	0.137	0.104	0.448	0.321	0.117	0.115	1.000			
(10) Remittance $paid^2$	0.371	0.222	0.149	0.279	0.630	0.439	0.263	0.266	0.655	1.000		
(11) Remittance $received^2$	−0.015	0.125	0.142	−0.066	0.402	0.707	−0.088	−0.085	0.518	0.746	1.000	
(12) foreign $asset^2$	−0.031	0.135	0.589	−0.087	0.129	0.237	−0.116	−0.115	0.241	0.294	0.240	1.000

Source: STATA version 15 output

Table AIII. Correlation matrix

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