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RESEARCH ARTICLE

Does democracy help reduce environmental degradation?

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Abstract

The main purpose of this study is to examine the democracy–environmental degradation nexus in 26 Organization for Economic Cooperation and Development (OECD) countries from 1990 through 2015 by using panel data estimation methods, performing well under cross-sectional dependence. Empirical results are as follows: (i) Tests show that cross-section dependence exists among panel members, and slope coefficients are heterogeneous, respectively, and (ii) long-term coefficient estimation results with Augmented Mean Group estimator show that democracy, non-renewable energy consumption, and real income per capita have statistically significant negative effects on environmental quality, whereas renewable energy consumption has a positive effect. There is also no statistically significant relationship between urbanization and environmental quality. These findings show the poor functioning of democracy in addressing environmental issues among OECD countries; therefore, raising environmental quality conflicts with the Sustainable Development Goals (SDGs) of creating strong institutions and economic growth targets. Moreover, promoting renewable energy consumption may be an effective alternative in reducing environmental degradation; therefore, it can be said that promoting clean energy use and raising the SDG environmental quality targets are in harmony.

Keywords Environmental quality · Renewable energy · Non-renewable energy · Ecological footprint · Democracy · Sustainable development goals

Introduction

To discuss the future of global development policies, the United Nations Sustainable Development Conference was held in Rio de Janeiro in 2012. The primary objective of the conference was to find sustainable solutions for urgent environmental, political, and economic issues affecting poverty-reducing Millennium Development Goals (MDGs), which had been only partially successful (United Nations 2019a). To fully achieve the MDGs and make those gains sustainable and to establish a better quality of life in underdeveloped countries, 17 key topics were introduced as SDGs, which planned to be replaced with MDGs. As in the original MDGs, these SDGs focused on ensuring environmental protection and combating climate change, with Goal 13 emphasizing that climate change has affected every country in the world and that environmental degradation and emissions have risen to historically high levels. Without action against environmental degradation and climate change, the world's average surface temperature is likely to surpass three degrees centigrade this century. Moreover, substituting carbon-based energy with cleaner, renewable sources such as wind and solar power would help diminish emission levels and encourage both developed and developing countries to move toward low-carbon technology. In addition, the lack of consideration or emphasis for institutions in the MDGs was remedied with Goal 16, which recommended building strong institutions to create peaceful and inclusive societies, promoting transparent regulations, and protecting individual and human rights around the world (United Nations 2019b).

It can be clearly seen that each SDG topic is strongly correlated with the other one. This raises questions about whether there is congruence in the agreement, such as harmony or contradiction between SDGs. Many discussions have been made to unveil how the SDGs interact. When drafting the SDGs, the parties presumed that the objectives of economic

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growth and environmental sustainability would become less contrary to improvements in efficiency; however, researchers have expressed different remarks based on their researches. According to Hajer et al. (2015), despite having the potential to be a guiding star for achieving shared and lasting prosperity, SDGs lack the framework to consistently address environmental concerns. They also point out that ecological goals for reducing biodiversity loss and combating climate change do not specify any target dates or criteria for fulfillment. In contrast, Pongiglione (2015) asserts that SDGs are not only just goals but also they promote each other to achieve other objectives essential for human development. For instance, improvements in sustainable agriculture increase agricultural productivity, which increases food security and leads to reaching the zero-hunger goal. However, Pogge and Sengupta (2015) assert that despite their positive aspects, the SDGs are far from fulfilling the inspiring purpose of eradicating poverty at all levels. They also find that Goal 13 lacks a concrete commitment to combating climate change and lowering emissions. According to Gupta and Vegelin (2016), SDGs appear to prioritize economic inclusiveness over ecological inclusiveness, thus creating an opposition between economy-based and ecology-based targets. Furthermore, Hickel (2019) states that reducing carbon emissions and resource use, which is a prerequisite for achieving decent work and economic growth targets (Goal 8), cannot be achieved with a 3% global economic growth rate.

Although most SDG researches have focused on the economic growth and environment nexus, the institutions and environment nexus have largely remained unexplored. Particularly, how democracy and environment interact was not made clear as well; and, different approaches asserted by researchers to unveil the theoretical background of democracy-environment nexus. Olson (1996) states that compatibility nexus between democracy and economic growth means that democracy increases economic growth as well as resource use; hence, it can be said that democracy does not promote actions on diminishing environmental pollutions and emissions. In other words, democracy creates a better investment climate by protecting private property rights and promoting individual entrepreneurship, which boosts economic growth, raises resource use, and hurts the environmental quality. Hillman and Ursprung (1992) stated that the effect of democracy on the environment varies by depending on the institutional mechanism of policy choice. The majority of society determines the policies in case of the existence of direct democracy. Therefore, environmental policies are determined by median voters, and policy-makers cannot adopt policies based on discretion. However, the policy-makers adopt discretion-based policies in case of representative democracy. The existence of representative democracy could lead to the arise of principal-agent problems. In such a case, individuals cannot monitor policies determined by agents, and decisions of policy-makers can be affected by lobby groups. Dryzek (1987) asserts that democracy is a regime in which lobbying groups seeking profit maximization have a significant political impact. Thus, the government might be affected by lobbying and may prioritize private interests over the public interest (Olson 1982). In contrast, autocratic regimes might deny lobbying demands that hurt environmental quality in favor of the public interest. Beyond that, because of political myopia, democratically elected governments might also be more lacking in commitment to long-term action plans than nonelected autocratic regimes (Bernauer and Koubi 2009). In other words, pollution abatement requires long-term commitment, and democratically elected governments might be unwilling to choose policies that limit resource use and slow economic growth down instead of vote-saving policies such as boosting economic growth. Therefore, democratically elected governments might be less successful in providing public goods such as a clean environment than nonelected regimes.

Adams and Acheampong (2019) emphasized that democracy promotes civic competence and gives awareness to citizens for differentiating public and individual interests. Democracy gives freedom of choice to individuals; therefore, citizens could freely choose the environmental policies by the voting mechanism. Moreover, autocratic regimes fail to provide public goods; hence, the provision of a clean and sustainable environment may not be achieved in autocracies (Olson 1996). According to Payne (1995), individuals are free to learn about the environment and ecological policies and can express their opinions, priorities, and putting political pressure on the government through voting (Acemoglu and Robinson 2006). Moreover, in democratic systems, individuals have greater access to information about environmental issues through freedom of the press. They also have the right to organize and lobby for environmental protection at both national and international levels (Kinda 2011). Pande (2003) points out that "a basic premise of representative democracy is that all those subject to policy should have a voice in its making." Therefore, individuals living in democratic societies have more influence than those living in autocratic systems in which people are not allowed to express opinions on socio-economic or ecological issues. Thus, demands for better environmental quality can be easily transmitted in the decision-making process and can force leaders to raise environmental standards. McCloskey (1983) and Payne (1995) assert that democratic governments are more sensitive to individual demands on ecological issues, which could encourage them to fulfill responsibilities and commitments under international treaties. Moreover, they emphasize that in autocratic systems individuals are not allowed to freely express their opinion on socio-economic issues, as well as ecological ones, they are not allowed to organize, and access to information without no cost is almost impossible.

In light of these conflicting thoughts, there is no apparent consensus about how democracy affects environmental degradation. The main objectives of this paper are to investigate the democracy–environmental degradation nexus in 26 OECD countries by using data available from 1990 to 2015. Former literature examining determinants of environmental pollution focused on economic and energy-based factors in OECD countries. However, institutional determinants of environmental degradation, particularly democracy, were ignored. There is a lack of knowledge about how democracy and the environment interact in OECD countries. To the best of our knowledge, this is the first study attempting to unveil democracy and environment nexus in OECD countries. Therefore, this study could be a key for policy-makers to make inferences to establishing synergy between democracy and the environment. Second, we employed ecological footprint, which considers agricultural, water, weather, and forest side of environmental pollution, as an indicator of environmental pollution to study environmental degradation more comprehensively. Third, the estimation methods used in the former literature do not address the cross-sectional dependence that frequently occurs in panel data estimations. It could be clearly seen in environmental literature that international initiatives have taken by countries such as the Stockholm Conference, Rio Conference, and the Kyoto Protocol. Besides, it could be clearly seen that many common environmental goals and partnerships are envisaged in both MDGs and SDGs. This global environmental diplomacy and these hundreds of multilateral agreements have led to cohesiveness and interdependency among countries (Hajer et al. 2015; Erdogan and Acaravci 2019). Therefore, it can be said that ignoring cross-section dependence could cause biased estimations and hypothesis tests (Sarafidis et al. 2009; Chudik and Pesaran 2013). This paper employs panel data estimation methods that perform well under cross-section dependency to avoid biased estimations and aims to contribute to filling the existing gap in the literature.

Literature review

Although the subject of drivers of environmental pollution has been an attention-grabbing research field for researchers (see Shahbaz and Sinha 2019), the institution-environment nexus has not been widely investigated. Therefore, it could be said that there is a smaller number of studies in this field compared with the number of researches on economic and demographic determinants of environmental deterioration. The prominent studies on democracy and environmental pollution relationship can be reviewed as follows.

Fredriksson et al. (2005) investigate democracy and environmental policy relationship in 94 countries for the years of 1993, 1996, and 2000 by using several estimation methods which do not consider cross-sectional dependence. Their findings show that a rise in political competition increases the stringency of environmental policies, whereas political participation has no significant effects on the stringency of environmental policies. In addition, they show that any increase in real GDP reduces the stringency of environmental policies. Farzin and Bond (2006) examine democracy and environmental pollution relationships in a set of countries for the period of 1980–1996 by employing fixed effect (FE) estimation method. They reveal that democracy has a decreasing effect on carbon emission, while it has an increasing effect on nitric oxide. Furthermore, GDP has an increasing effect on both those pollution indicators. Pellegrini and Gerlagh (2006) investigate democracy-environmental protection stringency nexus in 44 countries for the period of 1980–1985 by employing the ordinary least squares (OLS) method. Their findings are in favor of the non-existence of a statistically significant relationship between democracy and environmental protection stringency, while there is a positive and statistically significant relationship between GDP and environmental protection stringency. Li and Reuveny (2006) investigate relationships between democracy and several environmental indicators in a set of different samples and periods. Overall results mostly indicate that democracy has negative and statistically significant effects on environmental degradation. Furthermore, the effects of income and trade vary based on environmental indicators and estimation methods.

Bernauer and Koubi (2009) investigate democracy and sulfur dioxide relationships in 42 countries for the period of 1971–1996 by using random effect (RE) method. Their findings show that democracy reduces environmental pollution, while income has statistically insignificant effects on pollution. Arvin and Lew (2011) examine democracy's effect on several environmental indicators in 141 developing countries for the period of 1976–2003 by employing generalized OLS. According to the results, an increase in democracy positively affects carbon emissions and water pollution; whereas negatively affects deforestation damage. Furthermore, an increase in income level reduces carbon emissions, while tots water pollution and deforestation damage up. Buitenzorgy and Mol (2011) examine democracy and deforestation rates in 177 countries for the period of 1990–2000 by employing the OLS method. Their findings suggest that democracy has a positive and statistically significant effect on deforestation rate, while estimation results for income level mostly show that no statistically significant relationships exist between GDP and deforestation results. Gani and Scrimgeour (2014) investigate voice-accountability and water pollution nexus in 21 OECD countries for the period of 1998–2005 by employing the generalized method of moments (GMM) approach. Their findings suggest that an increase in voice and accountability exacerbates water pollution, whereas increases in both GDP and trade diminish water pollution. You et al. (2015) examine democracy and carbon emission relationship in a cross-section of countries for the period of 1985–2005 by using pooled OLS, FE, and quantile regression method (QRM) approaches, and their pooled OLS findings show that democracy reduces carbon emissions, whereas FE findings show that democracy increases carbon emissions, and QRM findings show mix results. Besides, real income per capita (real GDP) positively affects carbon emissions, while findings for trade openness are overwhelmingly favored of the existence of a statistically insignificant effect on emissions. Adams et al. (2016) investigate democracy-environmental pollution nexus in Ghana by Fully Modified Phillips-Hansen method from 1965 to 2011. They reveal that an increase in the democracy level decreases environmental pollution levels. Moreover, trade openness reduces environmental degradation while urbanization increases.

Adams and Klobodu (2017) examine democracy and carbon emission relationships in 38 African countries for the period of 1971–2011 by using dynamic OLS (DOLS). The findings indicate that an increase in the democracy level helps to reduce carbon emissions in those African countries. In order to unveil democracy and ecological footprint nexus, Charfeddine and Mrabet (2017) employ fully modified OLS (FMOLS) and DOLS for the period of 1975–2007 in 15 Middle East and North Africa (MENA) countries. Their FMOLS findings suggest that democracy increases ecological footprints, whereas DOLS findings indicate that democracy does not have a statistically significant effect on ecological footprint. In addition, both FMOLS and DOLS findings reveal that real GDP has a positive effect on environmental degradation. In order to investigate the effect of democracy on carbon emissions level, Lv (2017) employs OLS and QRM in 19 emerging market economies for the period of 1997-2010. According to the results, democracy increases carbon emissions levels. Furthermore, an increase in income level also raises carbon emissions, whereas there are no statistically significant relationships between trade openness and carbon emissions. Kashwan (2017) investigates democracy-protected areas nexus in 137 countries in 2012 by using generalized linear models. The overall results show that democracy has a positive effect on the size of protected areas, while based on the model, the effect of GDP varies. Farzanegan and Markwardt (2018) investigate democracy-environment nexus in 17 the Middle East and North Africa (MENA) countries for the period of 1980–2005 by employing several estimation methods that do not consider cross-sectional dependence. Their findings suggest that increasing democracy might be an effective tool for reducing environmental pollution. Besides, their findings overwhelmingly indicate that real GDP positively affects environmental pollution, whereas trade openness does not have a statistically significant effect on environmental degradation. Kim et al. (2019) investigate democracy-environmental quality nexus in 132 countries for the period of 2014–2016 by using the RE method. Their findings suggest that an increase in the quality of democracy raises the level of environmental quality, whereas the increase in income level diminishes the level of environmental quality. Adams and Acheampong (2019) examine democracy and carbon emission relationships in 46 Sub-Saharan African countries for the period of 1980–2015 by employing several estimation approaches. They find that democracy promotes to reduce carbon emissions. Besides, renewable energy consumption also reduces carbon emissions level, while trade openness increases. Furthermore, GDP mostly has a statistically insignificant effect on carbon emissions. Adams and Nsiah (2019) investigate democracy and environmental degradation nexus in 28 Sub-Saharan African Countries from 1980 to 2014 by employing the FMOLS and GMM methods. They reveal that less-democratic countries tend to pollute the environment more and both renewable and non-renewable energy has a positive effect on environmental degradation. Usman et al. (2020) examine democracy and environmental quality in South Africa from 1971 to 2014 by using the FMOLS method. They confirm the existence of the Environmental Kuznets Curve (EKC) and reveal that there is no significant nexus between democracy and the environment.

The following common features could be observed in the literature review. First, despite the use of different samples, to the best of our knowledge, there is no study investigating democracy-environmental quality nexus in OECD countries. Second; distinctively, this study uses the ecological footprint, which is a more complex indicator of environmental degradation. The use of ecological footprint may allow us to make comprehensive inferences on environmental issues. Third, a great part of the papers, examining democracy-environmental degradation nexus, employ panel data approaches; however, the panel data techniques used in those papers are not able to cope with cross-sectional dependence, generally occurring in multi-country studies. In such a case, estimated coefficients and hypothesis tests may be biased (Chudik and Pesaran 2013; Erdogan et al. 2020a). In order to avoid biased estimations and make consistent policy proposals, panel data methods performing well under cross-sectional dependence are employed in this study. Fourth, this study seeks to investigate how to create synergy between institutional and environmental aims of SDGs in the OECD sample, and aims to make distinctive contributions to fill that gap in the literature.

Theoretical background, model, data, and methodology

Theoretical background, model, and data

The nexus of democracy and the environment can be explained by using two approaches. The first approach argues that democracy helps to reduce environmental degradation. Individuals can access grater information about environmental issues, express their opinions, and priorities through freedom of the press, can right to organize and lobby for environmental protection at both national and international levels, and putting political pressure on the government through voting in democratic societies. Besides, democratic governments are more sensitive to individual demands on ecological issues, which could encourage them to fulfill responsibilities and commitments under international treaties. The second approach asserts that an increase in democracy enhances economic growth and resource use and exacerbates environmental degradation. Furthermore, democratically elected may choose to boost economic growth to increase welfare and save votes for coming to power for one more period. Therefore, democratically elected governments may tend to fail to combat environmental degradation. We used the democratic accountability index as an indicator of democracy. The democratic accountability index is a measure of how well the government responds to its people and fundamental civil liberties and political rights. It is measured on a 0–6 scale that higher index values show a higher level of democracy and vice versa. Moreover, we used the ecological footprint as an indicator of environmental degradation. The ecological footprint is accepted more holistic and inclusive compared with other environmental indicators (Ulucak and Lin 2017; Destek and Sarkodie 2019; Solarin 2019) because of including cropland, grazing, fishing, forest, CO_2 emission, and infrastructure footprints. It is a measure of how much resources we demand from nature and how much resources we must provide to nature in return; hence, a higher ecological footprint means higher environmental degradation.

Economic growth and environmental quality nexus have been intensively studied since the study of Grossman and Krueger (1991). Therefore, we included economic growth in our model as a control variable. Afterward, disaggregate energy consumption have gained importance in empirical analyses (see Cole et al. (1997); Richmond and Kaufmann (2006)). As it is emphasized in SDGs (Goal 7), extending the use of renewable energy consumption would support creating an inclusive and sustainable economic environment, and surely ease to reduce effects of climate change and environmental degradation. Because of those reasons, renewable energy consumption is expected to reduce environmental degradation. Conversely, the exacerbating effect of non-renewable energy consumption on environmental quality is widely accepted. Finally, Sinha et al. (2019) and Sarkodie et al. (2020) impressed that urbanization can be one of the important determinants of environmental quality in both developing and developed countries. However, there is no consensus on the effect of urbanization on environmental quality (see Danish et al. (2020)). On the one hand, urbanization can lead to environmental problems by destroying ecological areas, increasing fossil fuel consumption, and resource use, due to the increase in demand for housing and transportation, and industrial production. On the other hand, as urban inhabitants have higher incomes and opportunities to access higher education; therefore, the demands for a clean environment could increase along with environmental awareness. Moreover, urbanization can ease environmental problems by creating positive externalities, economies of scale, and efficient public services such as pipeline water, health services, proper waste management, and environment-friendly infrastructure (Pata 2018a; Danish and Wang 2019; Erdogan 2020). Therefore, it may be said that one is not able to judge the overall effect of urbanization on environmental degradation. In other words, either urbanization could reduce environmental pollution or mounts it up. Based on these theoretical discussions, the impact of democracy on environmental degradation is investigated with a linear model as shown below (Eq. 1). Due to data constraints, the annual data used in this study covers from 1990 to 2015 for 26 OECD countries.

$$\begin{aligned} \mathrm{LnEF}_{i,t} = {} & \beta_0 + \beta_1 \mathrm{LnGDP}_{i,t} + \beta_2 \mathrm{LnRNEC}_{i,t} \\ & + \beta_3 \mathrm{LnNRNEC}_{i,t} + \beta_4 \mathrm{LnDMC}_{i,t} \\ & + \beta_5 \mathrm{LnUR}_{i,t} + d_i(\varphi_i) + u_{i,t} \end{aligned} \quad (1)$$

where t represents the time period (1990–2015), i is the cross-section (26 OECD countries), and φ is the unobserved common factors. The β_1, β_2, β_3, β_4, and β_5 are the parameter coefficients, β_0 is the constant, and u is the error term. LnEF is the log of ecological footprint per capita, LnGDP is the log of the gross domestic product per capita (constant 2010 US$), LnRNEC is the log of renewable energy consumption calculated as a share of renewable energy consumption in total final energy consumption, LnNRNEC is the log of non-renewable energy consumption calculated as a share of fossil fuel energy consumption in total final energy consumption, LnDMC is the log of democratic accountability index, and LnUR is the log of urban population (% of the total population). Consequently; GDP per capita, renewable energy consumption, non-renewable energy consumption, and urban population were obtained from the World Development Indicators Online Database (2019). However, the democratic accountability index was obtained from International Country Risk Guide that published by the PRS Group (International Country Risk Guide 2018), and the ecological footprint per capita was obtained from the Global Footprint Network (2019).

Cross-sectional dependency and slope homogeneity

The possible dependence of errors could occur due to the omitted common effects, spatial effects, and the relationship between socio-economic networks; furthermore, it could arise as a result of unobserved general shocks, using a single currency, common agro-climate environment, and policies adopted by the central authority, and so on (Basak and Das 2018: 2; Chudik and Pesaran 2013: 2). Traditional panel estimators that do not consider cross-sectional dependency can produce misleading or even inconsistent parameters based on the extent of cross-sectional dependency and has either low test size and power or over test size or power (O'Connell 1998; Sarafidis et al. 2009; Baltagi and Pirotte 2010; Chudik and Pesaran 2013; Basak and Das 2017). Hereby, the cross-sectional dependency must be tested in the first stage of empirical analysis; to this end, we employed the Bias-Adjusted LM (LM_{adj}) test developed by Pesaran et al. (2008).

In addition to the cross-sectional dependency, another important issue to be investigated is whether the slope coefficients are homogeneous. In most empirical studies, it is generally assumed that the slope coefficients are homogeneous. However; this pre-assumption does not reflect the reality, and if characteristic features of the countries, firms, etc., are not included in the panel data models, this would lead to biased estimation and inference (Pesaran and Yamagata 2008: 50; Nazlioglu et al. 2011: 6618; Breitung et al. 2016:166). The effects of economic growth, renewable and non-renewable energy consumption, and democracy on environmental quality may depend upon the energy, development, and institutional policies of countries. The assumption of slope homogeneity for OECD countries in examining the nexus between these variables may be misleading. Therefore, it is important to investigate whether slope homogeneity is valid for reliable findings before applying standard panel data techniques. The homogeneity of the slope coefficient was investigated with the delta tilde test, denoted $\widetilde{\Delta}$, and delta tilde adjusted test denoted $\widetilde{\Delta}_{adj}$ that developed by Pesaran and Yamagata (2008)[1].

Estimation method

It is clearly known that the traditional panel cointegration estimators do not consider cross-section dependency. To overcome the cross-section dependency issue, the Augmented Mean Group (AMG) estimator developed by Eberhardt and Bond (2009) and Eberhardt and Teal (2010) was employed. AMG approach allows the estimation of coefficients of variables that have different levels of stationarity under cross-sectional dependence. Furthermore, the AMG approach allows to slope heterogeneity and gives robust results under even the variables are cointegrated or not cointegrated. In that case, it could be said that there is no need to implement any unit root and cointegration methods as a preliminary analysis before implementing the AMG approach. Ultimately, the AMG method performs well under possible endogeneity and gives robust heterogeneous or homogenous coefficient estimations (Eberhardt and Bond 2009: 5; Parker and Liddle 2016: 40; Eberhardt and Teal 2013). The parameters are obtained in two stages with the AMG estimator. First, it augments the pooled regression model with time dummies and this model (2) is estimated by first difference OLS (Eq. 2):

$$\Delta y_{it} = \beta \Delta x_{it} + \sum_{t=2}^{T} \lambda_t \Delta D_t + e_{it} \tag{2}$$

$$y_{it} = a_i + \beta_i x_{it} + d_i(\varphi_i) + e_{it} \tag{3}$$

where Δ is the first difference operator, y_{it} is the dependent variable, x_{it} is set of regressors, D_t is time dummies (starting from the second period as they are differenced) that used to estimate the dynamic effect, and λ_t is coefficients of time dummies. In the second stage of the estimation procedure, coefficients of time dummies (λ_t) that are collected in the first stage are turned into a variable (φ_t) shared across panel units. The variable φ_t represents the unobserved common factors that are potentially driving the variables in each panel unit. Ultimately, Eq. 3 is estimated for each section and group-specific model parameters are averaged across the panel (Neal 2015: 16-17; Atasoy 2017: 737).

Empirical results

Cross-sectional dependence and slope homogeneity tests result denoted in Table 1. According to the results of the cross-sectional dependency test, the null hypothesis of no cross-sectional dependency is rejected at a 1% level. One can expect the cross-sectional dependency in OECD ecological footprint per capita data because of the following reasons: (i) common agro-climate environment, (ii) common global shocks like the 2008 Financial Crisis, (iii) initiatives and agreements since the Stockholm Conference, and (iv) shared institutions such as the International Energy Agency, United Nations, and aims that result from treaties such as Kyoto Protocol, MDGs, and SDGs. Based on these findings, it can be said that environmental degradation in 26 OECD countries is highly dependent on each other. Hence, environmental degradation shocks in one country would probably affect other countries.

Besides, the homogeneity tests indicate that the null hypothesis of slope homogeneity is rejected at a 1% level. This finding simply implies that panel estimation methods that impose homogeneity restrictions to the related variable would lead to misleading inferences. Therefore, in order to avoid inconsistency and misleading inferences, we used an AMG estimator which considers cross-sectional dependency and does not impose homogeneity restrictions on the variables.

[1] The bias-adjusted LM (LMadj), delta tilde, and delta tilde adjusted tests are widely used methods in economic literature; therefore, we did not introduce it one more again.

Table 1 Cross-sectional dependency and homogeneity tests results

Cross-sectional dependency tests			Homogeneity tests		
Test	Statistic	*p* value	Test	Statistic	*p* value
LM_{adj}	3.576	0.000	$\widetilde{\Delta}$	14.915	0.000
			$\widetilde{\Delta}_{adj}$	15.680	0.000

Table 2 presents the results of the AMG estimator. According to the estimation results, an increase in GDP per capita increases environmental pollution, and this finding supports the inferences of the EKC hypothesis for the initial period (Acaravci and Akalin 2017; Aslan et al. 2018; Pata 2018b; Destek and Sarkodie 2019; Erdogan 2020; Erdogan et al. 2020b). Although the GDP per capita in OECD countries has experienced a modest average growth level for a long time and their income level is very high compared with the rest of the world (OECD 2019), it is seen that the quality of the environment still decreases with the growth. The main reason for this could be the high use of non-renewable energy sources in the growth process and the use of old-fashioned production technologies. This segment of the findings is consistent with Fredriksson et al. (2005), Farzin and Bond (2006), You et al. (2015), Charfeddine and Mrabet (2017), Lv (2017), Farzanegan and Markwardt (2018), and Kim et al. (2019). However, this finding is not consistent with Pellegrini and Gerlagh (2006), Bernauer and Koubi (2009), Buitenzorgy and Mol (2011), Gani and Scrimgeour (2014), and Adams and Acheampong (2019). Moreover, an increase in renewable energy consumption reduces the ecological footprint, while an increase in non-renewable energy consumption exacerbates the ecological footprint, and these findings consistent with expectations and former literature. Although the polluting effect of fossil fuels on environmental pollution is widely known, overall, 82% of global energy consumption was sourced from non-renewables in 2017. Having such a high share of non-renewable energy consumption leads to a decline in fossil fuel reserves and exacerbates environmental problems, resulting in increased health risks and the threat of global climate change. According to the fifth report of the Intergovernmental Panel on Climate Change, the main cause of global warming and climate change is carbon dioxide emissions from the burning of fossil fuels (Chen et al. 2019: 208). In contrast, renewable energy consumption has the following advantages and opportunities: (i) has the potential to provide services with almost zero emissions of both air pollutants and greenhouse gases (Panwar et al. 2011: 1514), thus making it possible to combat global warming and climate change, increase air quality, and improve public health; (ii) can lead to social and economic development by increasing employment opportunities (Ellabban et al. 2014: 756); and (iii) can provide lower costs, stable energy prices, and supply reliability. This segment of the findings is consistent with Adams and Acheampong (2019). However, this finding is not consistent with Adams and Nsiah (2019).

Table 2 AMG estimator results

Variable	Coefficient	*t* statistic	Prob.
Income	0.944***	12.01	0.000
Renewable energy	− 0.120***	− 2.64	0.008
Non-renewable energy	0.486*	1.85	0.064
Democracy	0.066**	2.00	0.045
Urbanization	− 1.362	− 1.46	0.144
Constant	− 2.686	− 0.60	0.547
CDP	0.970***	7.79	0.000

Statistical significance indicated as * significant at 10%, ** significant at 5%, and *** significant at 1%. Variable CDP refers to the common dynamic process

Furthermore, the impact of urbanization on the ecological footprint is negative; yet this impact is not statistically significant. This segment of the findings is consistent with Liddle and Lung (2010), Sharma (2011), and Sadorsky (2014). However, this finding is not consistent with Adams et al. (2016), Ozturk et al. (2016), and Danish et al. (2020). Finally, the detrimental effect of democracy on environmental pollution is especially striking, and this finding contradicts a major part of the literature. This result illustrates the poor ability of democracy to solve environmental issues among OECD countries. In other words, democracy may protect individual property rights, promote entrepreneurial freedom, and encourage economic growth, but it may not help with reducing environmental pollution or provide clean and sustainable ecology. Buitenzorgy and Mol (2011) state that fledgling democracies could contribute to the deterioration of the environment; however, this logic may not apply to OECD countries. Although the OECD includes some young democracies, it also includes mature and strong democracies such as the UK, France, and the USA. Thus, making generalizations about a democracy's effect on environmental degradation based on its age and strength may be misleading. The adverse impact of democracy on the environment might be caused by its functioning dynamics rather than its maturity. For instance, lobbying groups that consist mostly of industry owners may pressure decision-makers to prioritize economic growth and development over ecological concerns, and environmental lobbying groups may not have as much impact. Moreover, because governments are elected for a limited period in democracies, their tenures occasionally expire without fulfilling their environmental commitments. For example, the USA signed the Paris Agreement under President Obama, but President Trump withdrew from the agreement. In other situations, political instability may sometimes prevent politicians from serving their terms of office, which could disrupt ecological actions and policies. This segment of the findings is consistent with Arvin and Lew (2011), Buitenzorgy and Mol (2011), Gani and Scrimgeour (2014), Lv (2017), and Charfeddine and Mrabet (2017). However, this finding is not consistent with Pellegrini and Gerlagh (2006), Li and Reuveny (2006), Bernauer and Koubi (2009), Adams et al. (2016), Adams and Klobodu (2017), Kashwan (2017), Farzanegan and Markwardt (2018), Kim et al. (2019), Adams and Acheampong (2019), Adams and Nsiah (2019), and Usman et al. (2020).

Conclusions and policy implications

The MDGs were a major milestone for promoting universal economic development as well as fighting against environmental degradation. However, assuming both economic development and environmental degradation require a comprehensive and holistic approach, reducing these complex issues to an eight-goal road map was not a sustainable solution. Therefore, to remedy the deficiencies of MDGs, the SDGs, announced in 2012 and instituted in 2015, were designed. However, the SDGs ignited a new debate about whether the goals are antithetical. The institutions, as well as democracy–environment interaction, are one of these discussion topics, and these discussions are far from reaching a consensus. To contribute to unveiling the democracy-environmental pollution nexus, this study explores the democracy–environmental degradation nexus from 1990 through 2015 in 26 OECD countries using the ecological footprint, a comprehensive environmental indicator, as a dependent variable and GDP per capita, renewable and non-renewable energy consumption, democratic accountability index, and urbanization as regressors.

In the first part of our analysis, we performed cross-sectional dependency and homogeneity tests, which revealed that there is a cross-sectional dependence in the panel model and the slope coefficients are heterogeneous. To estimate the long-term relationship between variables, we used the AMG approach in the second part of our analysis. The AMG estimation results and its corresponding policy implications are as follows: an increase in economic growth decreases environmental quality. To eliminate the environmental cost of economic growth, it would be better to adopt a more inclusive and eco-friendly development approach that substitutes pollutant-production technology based on nonrenewable resources, with technologies that use eco-friendly renewable resources.

Democracy has an aggravating effect on environmental degradation. Therefore, the regulatory agencies could reduce the adverse effect of democracy on the environment by limiting the power of lawmakers to permit excessive resource use. Thus, by deflecting the impact of private economic interests through government regulation, the adverse effect of democracy on the environment would be reduced. In addition, to ensure the sustainability of environmental policies, governments should declare an “ecological constitution,” which is not affected by political elections and thus cannot be easily changed. Furthermore, decision-makers should create new platforms for demanding environmental improvements and ensure that inspection mechanisms are put in place to monitor these changes.

While non-renewable energy consumption has a negative impact on environmental quality, renewable energy consumption has a positive impact. This finding indicates that countries with a high share in renewable energy consumption could provide a sustainable solution to environmental problems. Therefore, to ease the environmental burden of economic development, decision-makers should promote the consumption of renewable energy. Furthermore, a growth approach that uses resources more efficiently provides eco-friendly transport facilities, and adopts greener production technologies, not pushed by unwise consumption, is necessary. Such a growth and development approach could help eliminate poverty without destroying forests, polluting air and water, and harming agriculture. Such major policy changes require international collaboration and initiatives, and international organizations such as the UN’s Sustainable Development Solutions Network should actively encourage the adoption of the green-growth approach in environmental diplomacy.

Authors’ contributions *GA:* formal analysis, writing—original draft; writing—review and editing. *SE*: conceptualization, investigation, writing-original draft.

Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Competing interests The authors declare that they have no competing interests.

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References

Acaravci A, Akalin G (2017) Environment–economic growth nexus: a comparative analysis of developed and developing countries. International Journal of Energy Economics and Policy 7(5):34–43

Acemoglu D, Robinson JA (2006) Economic origins of dictatorship and democracy. Cambridge University Press

Adams S, Acheampong AO (2019) Reducing carbon emissions: the role of renewable energy and democracy. Journal of Cleaner Production 240:118–245

Adams S, Klobodu EKM (2017) Urbanization, democracy, bureaucratic quality, and environmental degradation. Journal of Policy Modeling 39:1035–1051

Adams S, Nsiah C (2019) Reducing carbon dioxide emissions; Does renewable energy matter? Science of The Total Environment 693: 133288

Adams S, Adom PK, Klobodu EKM (2016) Urbanization, regime type and durability, and environmental degradation in Ghana. Environmental Science and Pollution Research 23(23):23825–23839

Arvin BM, Lew B (2011) Does democracy affect environmental quality in developing countries? Applied Economics 43(9):1151–1160

Aslan A, Destek MA, Okumus I (2018) Bootstrap rolling window estimation approach to analysis of the Environment Kuznets Curve hypothesis: evidence from the USA. Environmental Science and Pollution Research 25(3):2402–2408

Atasoy BS (2017) Testing the environmental Kuznets curve hypothesis across the US: evidence from panel mean group estimators. Renewable and Sustainable Energy Reviews 77:731–747

Baltagi BH, Pirotte A (2010) Panel data inference under spatial dependence. Economic Modelling 27:1368–1381

Basak GK, Das S (2017) Intercept homogeneity test for fixed effect models under cross-sectional dependence: some insights. Journal of Econometric Methods, 6, online version.

Basak GK, Das S (2018) Understanding cross-sectional dependence in panel data. Available at SSRN: https://ssrn.com/abstract=3167337 or. https://doi.org/10.2139/ssrn.3167337

Bernauer T, Koubi V (2009) Effects of political institutions on air quality. Ecological Economics 68:1355–1365

Breitung J, Roling C, Salish N (2016) Lagrange multiplier type tests for slope homogeneity in panel data models. The Econometrics Journal 19(2):166–202

Buitenzorgy M, Mol APJ (2011) Does democracy lead to a better environment? deforestation and the democratic transition peak. Environmental and Resource Economics 48:59–70

Charfeddine L, Mrabet Z (2017) The impact of economic development and social-political factors on ecological footprint: a panel data analysis for 15 MENA countries. Renewable and Sustainable Energy Reviews 76:138–154

Chen Y, Wang Z, Zhong Z (2019) CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. Renewable energy 131:208–216

Chudik A, Pesaran MH (2013) Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. Journal of Econometrics 188(2):393–420

Cole MA, Rayner AJ, Bates JM (1997) The environmental Kuznets curve: an empirical analysis. Environment and development economics 2:401–416

Danish, Wang Z (2019) Investigation of the ecological footprints driving factors: what we learn from the experience of emerging economies. Sustainable Cities and Society 49:101626

Danish, Ulucak R, Khan SUD (2020) Determinants of the ecological footprint: role of renewable energy, natural resources, and urbanization. Sustainable Cities and Society 54:101996

Destek MA, Sarkodie SA (2019) Investigation of environmental Kuznets curve for ecological footprint: the role of energy and financial development. Science of the Total Environment 650:2483–2489

Dryzek JS (1987) Rational ecology: environment and political economy. Basil Blackwell, New York

Eberhardt M, Bond S (2009) Cross-section dependence in nonstationary panel models: a novel estimator. Paper presented at the Nordic Econometrics Conference in Lund Sweden.

Eberhardt M, Teal F (2010) Productivity analysis in global manufacturing production. In: Discussion Paper 515. University of Oxford, Department of Economics

Eberhardt M, Teal F (2013) No mangoes in the tundra: spatial heterogeneity in agricultural productivity analysis. Oxford Bulletin of Economics and Statistics 75(6):914–939

Ellabban O, Abu-Rub H, Blaabjerg F (2014) Renewable energy resources: current status, future prospects and their enabling technology. Renewable and Sustainable Energy Reviews 39:748–764

Erdogan S (2020) Analyzing the environmental Kuznets curve hypothesis: the role of disaggregated transport infrastructure investments. Sustainable Cities and Society, 102338.

Erdogan S, Acaravci A (2019) Revisiting the convergence of carbon emission phenomenon in OECD countries: new evidence from Fourier panel KPSS test. Environmental Science and Pollution Research 26:24758–24771

Erdogan S, Akalin G, Oypan O (2020a) Are shocks to disaggregated energy consumption transitory or permanent in Turkey? New evidence from fourier panel KPSS test. *Energy 197*:117174

Erdogan S, Adedoyin FF, Bekun FV, Sarkodie SA (2020b) Testing the transport-induced environmental Kuznets curve hypothesis: the role of air and railway transport. Journal of Air Transport Management *89*:101935

Farzanegan MR, Markwardt G (2018) Development and pollution in the Middle East and North Africa: democracy matters. Journal of Policy Modeling 40:350–374

Farzin HY, Bond CA (2006) Democracy and environmental quality. Journal of Development Economics 81:213–235

Fredriksson PG, Neumayer E, Damania R, Gates S (2005) Environmentalism, democracy, and pollution control. Journal of environmental economics and management 49(2):343–365

Gani A, Scrimgeour F (2014) Modeling governance and water pollution using the institutional ecological economic framework. Economic Modelling 42:363–372

Global Footprint Network (2019) Ecological footprint. Oakland, USA; [Online] (accessed 24.03.2019) Available from: http://www.footprintnetwork.org/en/index.php/GFN/.

Grossman GM, Krueger AB (1991) Environmental impacts of a North American Free Trade Agreement No. w3914, National Bureau of Economic Research.

Gupta J, Vegelin C (2016) Sustainable development goals and inclusive development. International Environmental Agreements: politics, law and economics 16(3):433–448. https://doi.org/10.1007/s10784-016-9323-z

Hajer M, Nilsson M, Raworth K, Bakker P, Berkhout F, De Boer Y, Rockström Y, Ludwig K, Kok M (2015) Beyond cockpitism: four insights to enhance the transformative potential of the sustainable development goals. *Sustainability 7*(2):1651–1660. https://doi.org/10.3390/su7021651

Hickel J (2019) The contradiction of the sustainable development goals: growth versus ecology on a finite planet. Sustainable Development 27(5):873–884

Hillman AL, Ursprung HW (1992) The influence of environmental concerns on the political determination of trade policy. The greening of world trade issues:195–220

International Country Risk Guide (2018) Political risk services. East Syracuse, NY USA; [Online] (accessed 15.07.2018) Available

from: https://www.prsgroup.com/explore-our-products/political-risk-services/.
Kashwan P (2017) Inequality, democracy, and the environment: a cross-national analysis. Ecological Economics 13:139–151
Kim S, Baek J, Heo E (2019) A new look at the democracy–environment nexus: evidence from panel data for high- and low-income countries. Sustainability 11:1–14
Kinda SR (2011) Democratic institutions and environmental quality: effects and transmission channels. https://ideas.repec.org/p/zbw/gdec11/46.html Data Accessed on 15.10.2019
Li Q, Reuveny R (2006) Democracy and environmental degradation. International studies quarterly 50(4):935–956
Liddle B, Lung S (2010) Age-structure, urbanization, and climate change in developed countries: revisiting STIRPAT for disaggregated population and consumption-related environmental impacts. Population and Environment 31(5):317–343
Lv Z (2017) The effect of democracy on CO2 emissions in emerging countries: does the level of income matter? Renewable and Sustainable Energy Reviews 72:900–906
McCloskey DN (1983) The Rhetoric of Economics. Journal of Economic Literature 21(2):481–517
Nazlioglu S, Lebe F, Kayhan S (2011) Nuclear energy consumption and economic growth in OECD countries: cross-sectionally dependent heterogeneous panel causality analysis. Energy Policy 39(10):6615–6621
Neal T (2015) Estimating heterogeneous coefficients in panel data models with endogenous regressors and common factors. Workblacking Paper.
O'Connell PGJ (1998) The overvaluation of purchasing power parity. Journal of International Economics 44:1–19
OECD (2019). Real GDP forecast (indicator). https://doi.org/10.1787/1f84150b-en (Accessed on 05 December 2019).
Olson M (1982) *The Rise and Decline of Nations*. Yale University Press, New Haven
Olson M (1996) Distinguished lecture on economics in government: big bills left on the sidewalk: why some nations are rich, and others poor. Journal of Economic Perspectives 10(2):3–24
Ozturk I, Al-Mulali U, Saboori B (2016) Investigating the environmental Kuznets curve hypothesis: the role of tourism and ecological footprint. Environmental Science and Pollution Research 23(2):1916–1928
Pande R (2003) Can mandated political representation increase policy influence for disadvantaged minorities? Theory and evidence from India. The American Economic Review 93(4):1132–1151
Panwar NL, Kaushik SC, Kothari S (2011) Role of renewable energy sources in environmental protection: a review. Renewable and Sustainable Energy Reviews 15(3):1513–1524
Parker S, Liddle B (2016) Energy efficiency in the manufacturing sector of the OECD: analysis of price elasticities. Energy Economics 58: 38–45
Pata UK (2018a) The effect of urbanization and industrialization on carbon emissions in Turkey: evidence from ARDL bounds testing procedure. Environmental Science and Pollution Research 25(8):7740–7747
Pata UK (2018b) Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: testing EKC hypothesis with structural breaks. Journal of Cleaner Production 187:770–779
Payne RA (1995) Freedom and the environment. Journal of Democracy 6(3):41–55
Pellegrini L, Gerlagh R (2006) Corruption, democracy, and environmental policy. The Journal of Environment and Development 15(3): 332–354
Pesaran MH, Yamagata T (2008) Testing slope homogeneity in large panels. Journal of econometrics 142(1):50–93
Pesaran MH, Ullah A, Yamagata T (2008) A bias-adjusted LM test of error cross-section independence. The Econometrics Journal 11(1): 105–127
Pogge T, Sengupta M (2015) The Sustainable Development Goals: a plan for building a better world? Journal of Global Ethics 1(1):56–64
Pongiglione F (2015) The need for a priority structure for the Sustainable Development Goals. Journal of Global Ethics 11(1):37–42
Richmond AK, Kaufmann RK (2006) Is there a turning point in the relationship between income and energy use and/or carbon emissions? Ecological Economics 56(2):176–189
Sadorsky P (2014) The effect of urbanization on CO2 emissions in emerging economies. Energy Economics 41:147–153
Sarafidis V, Yagamata T, Robertson D (2009) A test of cross section dependence for a linear dynamic panel model with regressors. Journal of Econometrics 148:149–161
Sarkodie SA, Owusu PA, Leirvik T (2020) Global effect of urban sprawl, industrialization, trade and economic development on carbon dioxide emissions. Environmental Research Letters 15(3):034049
Shahbaz M, Sinha A (2019) Environmental Kuznets curve for CO2 emissions: a literature survey. Journal of Economic Studies 46(1):106–168
Sharma SS (2011) Determinants of carbon dioxide emissions: empirical evidence from 69 countries. Applied Energy 88(1):376–382
Sinha A, Shahbaz M, Balsalobre D (2019) Data selection and environmental kuznets curve models-environmental kuznets curve models, data choice, data sources, missing data, balanced and unbalanced panels. In Environmental Kuznets Curve (EKC) (pp. 65-83): Elsevier.
Solarin SA (2019) Convergence in CO 2 emissions, carbon footprint and ecological footprint: evidence from OECD countries. Environmental Science and Pollution Research 26(6):6167–6181
The World Bank World Development Indicators (2019). Washington, DC; [Online] (accessed 25.03.19) Available from: http://data.worldbank.org/data-catalog/world-development-indicators.
Ulucak R, Lin D (2017) Persistence of policy shocks to Ecological Footprint of the USA. Ecological Indicators 80:337–343
United Nations (2019a) News on millennium development goals. https://www.un.org/millenniumgoals/ Data Accessed on 5.10.2019
United Nations (2019b) Goal 16: Peace, justice and strong institutions. https://www.un.org/sustainabledevelopment/peace-justice/ Data Accessed on 5.10.2019.
Usman O, Olanipekun IO, Iorember PT, Abu-Goodman M (2020) Modelling environmental degradation in South Africa: the effects of energy consumption, democracy, and globalization using innovation accounting tests. Environmental Science and Pollution Research 27(8):8334–8349
You WH, Zhu HM, Yu K, Peng C (2015) Democracy, financial openness, and global carbon dioxide emissions: heterogeneity across existing emission levels. World Development 66:189–207