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Oil rents, economic growth, and CO_2 emissions in 13 OPEC member economies: Asymmetry analyses

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Oil rents significantly contribute to income in OPEC member economies and could have environmental consequences. The present study explores the asymmetrical effects of oil rents on CO_2 emissions in 13 current OPEC economies using a period 1970–2019, and also tests the Environmental Kuznets Curve (EKC) hypothesis. Long-run results show that economic growth has a positive effect, and its square term has a negative effect on CO_2 emissions in Algeria, Congo, Gabon, Kuwait, and Saudi Arabia, which validate the EKC in these countries. However, a U-shaped effect of income growth on emissions is substantiated in Angola. Moreover, rising oil rents have positive effects on CO_2 emissions in Saudi Arabia, Angola, Congo, Equatorial Guinea, Iran, Iraq, Kuwait, and Libya, and have negative impacts in Algeria, Nigeria, and the UAE. Decreasing oil rents reduce CO_2 emissions in Angola, Equatorial Guinea, Libya, and Saudi Arabia, and increase emissions in Algeria. Moreover, asymmetrical effects of oil rents on emissions are found in Angola, Congo, Iran, Iraq, Kuwait, Nigeria, Equatorial Guinea, Saudi Arabia, and the UAE. The short-run results show that the EKC is validated in Algeria, Congo, and Libya. However, economic growth shows a monotonic positive impact on emissions in Nigeria, the UAE, and Venezuela. Increasing oil rents show a positive impact on emissions in Angola, Congo, Iran, and Kuwait and carry a negative impact in Algeria and the UAE. In addition, decreasing oil rents increase CO_2 emissions in Algeria, Gabon, Nigeria, and Saudi Arabia. We recommend Angola, Congo, Equatorial Guinea, Iran, Iraq, Kuwait, Libya, and Saudi Arabia to adopt tight environmental policies in times of increasing oil rents to avoid the negative environmental consequences of oil rents.

KEYWORDS

oil rents, economic growth, the EKC, the environmental Kuznets curve, the organization of the petroleum exporting countries (opec)

Introduction

Oil rents are the major source of income in oil-abundant OPEC economies and would have a scale effect in the oil-income-dependent OPEC economies. Consequently, oil rents would be responsible for greater energy consumption and pollution emissions. On the production side, oil production was responsible for 10.3 g of emissions on average from each megajoule of crude, which generated 1.7 gigatons of carbon dioxide in 2015 worldwide (Garthwaite, 2018). In 2020, on average, 13 OPEC economies emitted 2.73 oil emissions tCO_2 per person and 7.16 territorial emissions tCO_2 per person compared to the global average of 2.57 oil emissions tCO_2 per person and 5.18 territorial emissions tCO_2 per person, respectively. Thus, OPEC economies are emitting greater average CO_2 emissions per capita compared to the global average. In total emissions, OPEC economies are emitting 6.36% of global CO_2 emissions (Global Carbon Atlas, 2022). Globally, more than 50% of CO_2 emissions are from oil emissions and OPEC economies are highly dependent on the oil sector. For instance, as per data for 2021, the oil exports were 54.9% of total exports in OPEC. Moreover, OPEC carried 37.8% of world crude oil production and 33.2% of world petroleum exports (OPEC, 2021). Moreover, the oil rents were observed at 24.62% of Gross Domestic Product (GDP) on average in 13 OPEC economies during 1970–2019. However, the oil rents are not very smooth and have spikes due to the many international events.

Figure 1 reports the trends of oil rents percentage of GDP. A great fluctuation in oil rents was observed due to an oil price hike of 300% from October 1973 to March 1974 because of putting an embargo by OPEC on selected countries (Office of the Historian, 2022). After some declines, oil price got more than doubled in 1979. Later, oil prices and rents mostly declined till 1982 and fluctuated with ups and downs movements during 1982–1990. However, oil prices again got double in 1990 due to Iraq-Kuwait tension. The decade of the 2000s also faced a lot of fluctuations, and oil prices got their peak in July 2008. Afterward, oil prices declined sharply till December 2008 (Hamilton, 2009) and oil prices showed great fluctuations from 70$ to 120$ till November 2014. During 2014–2016, oil prices faced a deep decline due to a growing supply glut. During 2016–2019, oil prices started stabilizing but fetch up in a problem of COVID-19 due to a downturn in oil demand globally (OPEC, 2021). Figure 1 explains the story of the oil crisis and oil rents. All the OPEC economies have moved almost in the same directions and these fluctuations could have a deep impact on the economy and environment of the OPEC economies. For instance, the economic growth rate of OPEC economies was -5.2% in 2020 due to COVID-19 compared to the world's average of -3.3% (OPEC, 2021).

Oil rents may support the economic growth of oil-abundant economies. However, overdependence on natural resources may obstruct the development of other sectors, which is called Dutch Disease (Corden and Neary, 1982). Dutch Disease explains that increasing exports of the natural resource sector would appreciate the currency and exports of other sectors will become expensive consequently, which may reduce exports from other sectors. Moreover, the growth of the oil sector would decrease the concentration of a nation on other sectors as well. In addition, the natural resource curse hypothesis explains that the presence of natural resources would have political problems in a country. Hence, excessive dependence on natural resources would obstruct the process of economic growth (Auty, 1993). The natural resource curse can be termed an oil curse in the oil-abundant economies of the OPEC cartel. Excessive dependence on oil sources would hinder many economic, social, and political indicators, which would reduce the process of development (Shao and Yang, 2014). On the other

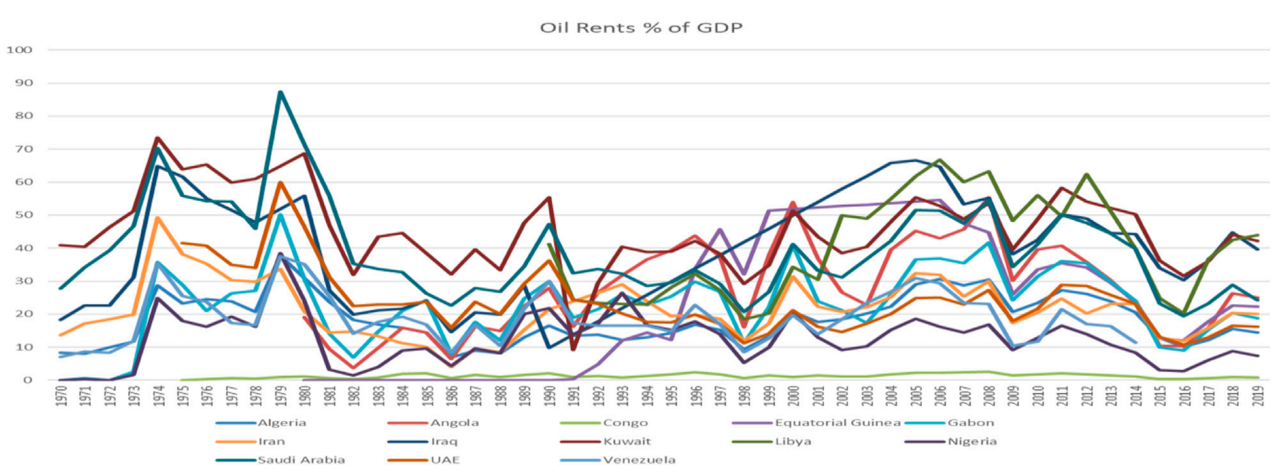

FIGURE 1
Trends of oil rents percentage of GDP during 1970–2019.

hand, Sachs (2007) claimed that the oil curse phenomenon is partially true, and it can happen in an economy if oil earnings are utilized for consumption purposes instead of investment purposes. It was suggested to invest the oil earnings in the growth of non-oil exports to avoid the Dutch Disease phenomenon. A vast literature has studied the impact of natural resources on economic growth and other macroeconomic indicators (Sachs and Warner, 1995; Dietz et al., 2007; Daniele, 2011; Bhattacharyya and Hodler, 2014; Cockx and Francken, 2016).

On the environmental side, many studies have investigated and corroborated the positive impact of natural resource rents on ecological or carbon footprint (Hassan et al., 2019; Nathaniel et al., 2021; Jahanger et al., 2022) and CO_2 emissions (Bekun et al., 2019; Adediyan et al., 2020; Joshua and Bekun, 2020; Khan et al., 2020; Nwani and Adams, 2021; Onifade et al., 2021; Shen et al., 2021; Huang and Guo, 2022). Alternatively, some studies also reported the negative effect of natural resource rents on the ecological footprint (Danish and Khan, 2020; Ulucak and Khan, 2020) and CO_2 emissions (Balsalobre-Lorente et al., 2018; Kongbuamai et al., 2020). Thus, resource rents do not have the same effect on the environment in different economies. In the same way, the exact effect of oil rents on emissions is an empirical question, which is a target of this present study to investigate in OPEC economies. Mogaddam (2022) argued that the oil sector from well to tank is highly responsible for CO_2 emissions. However, the test of oil rents on pollution emissions is scant in the present state of literature. Doing spatial analysis, Mahmood and Furqan (2021) explored the role of oil rents on GHGs emissions in six GCC countries. Still, comprehensive research is missing in the maximum sample of OPEC economies. Thus, the present study contributes to OPEC environmental literature by investigating the effects of oil rents on CO_2 emissions in all current OPEC members. In addition, this relationship is tested in an asymmetry setting to enhance the contribution of this study, as the literature suggested investigating this issue in asymmetrical analyses (Mahmood et al., 2020; Alvarado et al., 2021).

Literature review

Resource rents could play a significant role in resource-abundant OPEC economies and may support the economic growth of economies through generating income and employment (Sinha and Sengupta, 2019). Moreover, resource rents may also improve environmental quality if they could reduce the reliance on fossil fuel consumption (Balsalobre-Lorente et al., 2018). In oil-abundant economies, oil rents may generate the technique effect, if oil rents could invest in producing energy-efficient and clean energy technologies. Consequently, energy efficiency could help in the promotion of environmental sustainability (Alam M. S. et al., 2022a; Murshed et al., 2022a; Khan et al., 2022). Moreover, oil rents may also be utilized for economic diversification from the oil sector, which may generate a composition effect. Thus, oil rents would help in shaping the EKC hypothesis by promoting technique and/or composition effects in oil-abundant economies. There is limited empirical environmental literature on oil rents. However, a vast literature has examined the relationship between natural resource rents and pollution emissions.

At first, we discuss the literature corroborating the pleasant environmental effects of natural resource rents. For instance, Balsalobre-Lorente et al. (2018) confirmed a negative relationship between natural resources and CO_2 emissions in 5 EU economies from 1995 to 2016. In the same way, Kongbuamai et al. (2020) confirmed this relationship in the case of ASEAN from 1995 to 2016. Moreover, Shittu et al. (2021) corroborated a negative effect of resource rents on the ecological footprint in forty-five Asian economies from 1990 to 2018 and also confirmed a U-shaped relationship between ecological footprint and growth. In addition, a negative impact of resource rents on ecological footprint was confirmed by Danish and Khan. (2020) and Ulucak and Khan (2020) in BRICS economies and by Zafar et al. (2019) in the case of the United States. On the other hand, some studies explored the coal rents and pollution emissions nexus in BRICS countries. For instance, Adedoyin et al. (2020) explored the BRICS economies from 1990 to 2014 and found that coal rents and renewable energy reduced carbon emissions. However, carbon damage costs had a positive effect on CO_2 emissions.

Natural resource rents may also have environmental damages. For instance, Harbaugh et al. (2002) argued in the EKC theory that natural resources could be exploited in the early stage of growth and could pollute the economy. For instance, economic growth might accelerate industrialization, which could be responsible for natural resource exploitation and ecological problems (Kwakwa et al., 2020). Moreover, Badeeb et al. (2020) argued that natural resource abundance might promote a positive association between emissions and growth in the first stage of the EKC. In addition, it would reduce the strength of the negative relationship in the second stage of the EKC in resource-abundant economies. Thus, the natural resource abundance economies have a lesser chance to achieve the second phase of the EKC with increasing economic growth. Furthermore, using old technology in natural resource extraction might damage the environment (Shuai and Zhongying, 2009). In another argument, the natural resource would restrict human capital development and could reduce the chance of progress in technology (Gylfason, 2001). However, good-quality institutions might reduce the bad environmental consequences of natural resources (Tiba and Frikha, 2019).

In the empirical work, Jahanger et al. (2022) investigated 73 developing countries from 1990 to 2016. Natural resources and financial development raised, and innovation reduced the ecological footprint. Ulucak et al. (2020) explored the OECD countries from 1980 to 2016. Natural resources rents increased both carbon footprint and CO_2 emissions. Thus, natural resource extraction might be a threat to environmental sustainability. Moreover, renewable energy reduced and non-renewable increased ecological and carbon footprint. In the same way, Murshed et al. (2022b) corroborated the negative effect of renewable energy on carbon and ecological footprint in South Asia. Onifade et al. (2021) investigated the E7 economies from 1990 to 2016 and found that resource rents, income, and urbanization accelerated CO_2 emissions and ecological footprint. However, globalization reduced environmental degradation. Hussain et al. (2020) investigated 56 Belt and Road Initiative (BRI) economies from 1990 to 2014 and found that natural resource depletion accelerated energy usage and CO_2 emissions. Moreover, they found the feedback effects in the causality analyses of all investigated variables. In the same way, Khan et al. (2020) investigated 51 BRI countries from 1990 to 2016 and found that natural resources had positive effects on CO_2 emissions and energy consumption.

Baloch et al. (2019) investigated BRICS economies from 1990 to 2015 and found a positive impact of natural resources in South Africa, a negative effect in Russia, and insignificant effects on the ecological footprint in the rest of the 3 BRICS economies. The EKC hypothesis was also validated. Nathaniel et al. (2021) investigated BRICS economies and found that natural resources and income growth enhanced the ecological footprint. Ibrahim and Ajide (2021) explored BRICS economies from 1996 to 2018. Coal and fuel production and consumption and gas production increased carbon emissions. However, gas consumption reduced emissions. Moreover, resource rents, financial markets, and regulatory quality increased emissions. In the same way, Alam N. et al. (2022b) found that financial development increased carbon footprint and low-carbon energy resources reduced the carbon footprint. Moreover, Murshed et al. (2022c) found that financial inclusion reduced carbon productivity.

Nwani and Adams (2021) investigated 93 countries from 1995 to 2017. Natural resource rents, economic growth, and imports increased consumption and production-based carbon emissions in countries with low-quality governance and decreased production-based emissions in countries with high-quality governance. Tiba and Frikha (2019) investigated 26 African economies from 1990 to 2016 and corroborated the EKC hypothesis and resource curve hypothesis. Thus, natural resources degraded the environment. Moreover, Byakagaba et al. (2019) found that the exploration of oil and gas in Uganda developed social ills and environmental degradation. Adediyan et al. (2020) investigated Nigeria from 1986 to 2018 and found that resource rents had a positive effect on CO_2 emissions. Kwakwa et al. (2020) investigated Ghana from 1971 to 2013 and found that growth, urbanization, and natural resource extraction had positive effects on carbon emissions. However, trade openness and foreign aid helped to reduce emissions. Alam (2022) investigated and also found that trade helped reduce CO_2 emissions in Oman during 1980–2020. Moreover, Joshua and Bekun (2020) investigated South Africa from 1970 to 2017 and found that total natural resources rents showed a significant contribution to pollutant emissions.

Shen et al. (2021) examined 30 provinces of China from 1995 to 2017. Energy consumption, natural resources rents, and financial development increased emissions, while green investment reduced CO_2 emissions. In the same sample of provinces in China, Huang and Guo (2022) shared the same findings. Bekun et al. (2019) probed 16 EU countries from 1996 to 2014. Natural resource rents, nonrenewable, and income increased, and renewable energy reduced emissions. Wang et al. (2020) investigated G7 from 1996 to 2017 and found a positive effect of natural resources on CO_2 emissions. Nevertheless, the agriculture sector reduced emissions. Alvarado et al. (2021) suggested applying asymmetrical analyses to 17 Latin American economies and corroborated the asymmetrical effect of resource rents on the ecological footprint in quantile regression analyses using a period 1980–2016.

In the single country analysis, Shahbaz et al. (2020) investigated the United States from 1976 to 2016 and found that natural resources degraded the environment. However, education reduced carbon emissions. Hassan et al. (2019) examined Pakistan from 1970 to 2014 and found that resource rents increased the ecological footprint. Besides, the EKC hypothesis was validated. However, biocapacity and human capital could not affect the environment. Loganathan et al. (2020) investigated Malaysia from 1970 to 2018 and found a mix of the increasing and decreasing impact of natural resources on CO_2 emissions in different quantile of regression analyses and could not validate the EKC.

Some studies are conducted specifically for the OPEC economies. For instance, Liski and Tahvonen (2004) argued that due to the cartel of OPEC, pollution tax generated greater rents than the damage cost of pollution. Hence, the net welfare effect was positive for OPEC economies. Agboola et al. (2021) investigated Saudi Arabia from 1971 to 2016 and found that energy usage, resource rents, and income increased CO_2 emissions. However, oil rents reduced CO_2 emissions. Alfalih and Hadj (2022) investigated Saudi Arabia from 1985 to 2017 and found that financialization and natural resources rents improved environmental sustainability. Shehzad et al. (2022) corroborated that resource rents improved the environment and globalization degraded the environment in Algeria. Moreover, an N-shaped EKC was found between economic growth and ecological footprint. Ignoring resource rents, Saboori et al. (2016) investigated OPEC from 1977 to 2008 and corroborated the EKC hypothesis in 6 out of 10 investigated OPEC economies.

Benchekroun et al. (2020) investigated the cartel-fringe model and found that OPEC market power was a source of welfare loss net to climate change. Moreover, rising non-OPEC oil reserves decreased global welfare. Mahmood (2022) investigated the GCC countries from 1975 to 2019 and found that increasing oil and gas consumption increased emissions in the GCC region. However, declining oil consumption showed positive environmental effects in 4 out of 6 GCC economies, and decreasing gas consumption had similar effects in 3 out of 6 GCC countries. Interestingly, oil showed a larger effect than gas consumption. Moreover, the EKC was confirmed in two economies. Dong and Whalley (2012) investigated and found that the carbon taxes by large importers of oil, i.e., the US, the EU, and China, reduced the welfare of OPEC and increased the welfare of non-OPEC economies. However, these taxes reduced global emissions marginally. Moutinho et al. (2020) examined the 12 OPEC nations from 1992 to 2015 and found a U-shaped relationship between income and emissions. Moreover, energy usage increased, and trade decreased emissions. Moutinho and Madaleno (2022) tested the EKC in sectoral analyses of 9 OPEC economies from 1974 to 2016. The EKC was validated in extractive and manufacturing industries and commerce-related activities. Moreover, a U-shaped relationship was found in other analyzed sectors.

Some literature specifically investigated the relationships between the oil sector and the environment. For instance, Merrill and Orlando (2020) found that increasing political violence increased oil production, which accelerated carbon emissions in the MENA region. Ouédraogo et al. (2021) investigated African countries from 1980 to 2014. Oil resources increased CO_2 emissions in Angola and decreased CO_2 emissions in 4 African economies. Moreover, they found the EKC in Cameroon, Côte d'Ivoire, and Nigeria. However, a U-shaped relationship was found in Algeria and Morocco. Ozturk (2017) investigated Latin America from 1975 to 2013 and verified the negative effect of oil rents on emissions. Badeeb et al. (2016) found a positive effect of oil rents on commercial activity, which would increase energy demand and pollution. Liu et al. (2022) examined the role of resources' commodity price volatility in G7 economies from 1990 to 2020 and found that price volatility and economic growth accelerated carbon emissions. However, oil rents helped to reduce emissions. Mahmood and Furqan (2021) investigated oil rents and GHGs emissions relationship in GCC economies from 1980 to 2014 and confirmed the EKC. Moreover, oil rents had a positive impact on CO_2 emissions and a U-shaped effect on N_2O emissions. He et al. (2022) investigated China from 1971 to 2018 and found that oil rents and renewable energy reduced GHGs emissions. However, economic growth and natural resources increased GHGs emissions. Zhang et al. (2021) investigated 41 African countries from 1996 to 2018 and found that oil, gas, and coal consumption and their rents deteriorated the environmental quality. Moreover, technology through imports of goods and services helped to support environmental quality.

The reviewed literature discusses the relationship between natural resource rents and emissions. However, the studies on the oil rents and pollution emissions are limited and no study has conducted this analysis on all current members of OPEC. Hence, the present study contributes to this literature gap by inquiring about the oil rents-emissions nexus in asymmetrical analyses.

Methodology

Economic growth may be considered a major determinant of pollution emissions. Grossman and Krueger (1991) did a pioneer study finding a nonlinear impact of economic growth on pollution emissions, which is called the EKC hypothesis. In its first phase, a scale effect of economic growth demands more energy and is responsible for environmental degradation. Later, economic growth would create pleasant environmental effects through technique and/or composition effects by demanding a better environment to improve the standard of living (Grossman and Krueger, 1995). Resource rents would shape the EKC in natural resource-abundant economies (Harbaugh et al., 2002; Baloch et al., 2019; Tiba and Frikha, 2019; Badeeb et al., 2020). Particularly, oil rents carry a significant share in the GDP of each OPEC economy and would play a significant role in shaping the EKC. For instance, oil rents can be utilized for diversification policy from the oil sector and may also be utilized to develop clean technologies and energy sources. Hence, these both efforts would generate the technique and composition effects in the economy and may shift the economy from the first stage to the second stage of the EKC. Thus, the present study hypothesizes the effect of oil rents on CO_2 emissions, while testing the EKC hypothesis in OPEC economies, in the following way:

$$CO_t = f\left(Y_t, Y_t^2, OR_t\right) \quad (1)$$

CO_t represents the natural log of tCO_2 emissions per person, which is taken from the Global Carbon Atlas (2022). Y_t is the natural log of per head GDP in constant USD and Y_t^2 is a square of Y_t. OR_t is the natural log of oil rents percentage of GDP. The annual series of Y_t and OR_t are sourced from World Bank (2022). Data is taken for the UAE and Congo from 1975 to 2019, Angola and Equatorial Guinea from 1980 to 2019, Libya from 1990 to 2019, Venezuela from 1970 to 2014, and Algeria, Gabon, Iran, Iraq, Kuwait, Nigeria, and Saudi Arabia from 1970 to 2019, as the availability of data for targeted variables. Alvarado et al. (2021) suggested applying asymmetrical analyses to the relationship between resource rents and ecological footprint. In the same way, oil rents could have asymmetrical effects on CO_2 emissions. Because increasing oil rents may increase income and pollution emissions through the consumption of pollution-oriented products for a demand for a higher standard of living.

However, it is not necessary that consumption of such products will decrease emissions with a decrease in income. For instance, the Ratchet effect theory explains that to sustain such a standard of living of consumption patterns (Duesenberry, 1951), the demand for such products might not decrease with decreasing income. Hence, it is not necessary to have an equal impact of both rising and falling oil rents on emissions. Therefore, we split OR_t into positive and negative series using Shin et al. (2014):

$$\mathrm{ORP}_t = \sum_{j=1}^{t} OR_j^{+} = \sum_{j=1}^{t} \max\left(\Delta OR_j, 0\right) \tag{2}$$

$$\mathrm{ORN}_t = \sum_{j=1}^{t} OR_j^{-} = \sum_{j=1}^{t} \min\left(\Delta OR_j, 0\right) \tag{3}$$

ORP_t is a partial sum of positive change in OR_t in Eq. 2 and ORN_t is a partial sum of negative change in OR_t in Eq. 3. Now, the nonlinear model is as follows:

$$\mathrm{CO}_t = f\left(\mathrm{Y}_t, Y_t^2, \mathrm{ORP}_t, \mathrm{ORN}_t\right) \tag{4}$$

Our purpose is to apply Eq. 4 to all targeted OPEC economies to verify an asymmetrical effect of oil rents on emissions and to verify the existence of the EKC hypothesis in each individual country. Before moving towards long-run analyses, we apply Ng and Perron's (2001) methodology checking an order of integration in a model of each country. We use only MZa statistics out of 4 statistics of Ng and Perron (2001), because of the large number of series in the models of 13 countries. The test statistic is as follows:

$$MZ_a = \left[\left(y_T^d\right)^2 / T - \sum_{j=-T+1}^{T-1} \varnothing(j).k\left(\frac{j}{l}\right)\right] \Big/ 2\left[\left(y_T^d\right)^2 / (T)^2\right] \tag{5}$$

After checking the unit root, we will apply the Autoregressive Distributive Lag (ARDL) of Pesaran et al. (2001) to Eq. 4:

$$\begin{aligned}\Delta \mathrm{CO}_t = {} & a_0 + a_1 CO_{t-1} + a_2 Y_{t-1} + a_3 Y_{t-1}^2 + a_4 ORP_{t-1} + a_5 ORN_{t-1} \\ & + \sum_{i=1}^{l-1} b_{1i} \Delta CO_{t-i} + \sum_{i=0}^{m-1} b_{2i} \Delta Y_{t-i} + \sum_{i=0}^{m-1} b_{3i} \Delta Y_{t-1}^2 \\ & + \sum_{i=0}^{n-1} \left(b_{4i} \Delta ORP_{t-i} + b_{5i} \Delta ORN_{t-i}\right) + U_t \end{aligned} \tag{6}$$

$$\begin{aligned}\Delta \mathrm{CO}_t = {} & \partial ECT_{t-1} + \sum_{i=1}^{l-1} b_{1i} \Delta CO_{t-i} + \sum_{i=0}^{m-1} b_{2i} \Delta Y_{t-i} \\ & + \sum_{i=0}^{m-1} b_{3i} \Delta Y_{t-1}^2 + \sum_{i=0}^{n-1} \left(b_{4i} \Delta ORP_{t-i} + b_{5i} \Delta ORN_{t-i}\right) \\ & + V_t \end{aligned} \tag{7}$$

Eqs 6, 7 will be employed in each OPEC member's model. At first, a cointegration will be tested on a null hypothesis (H_0: $a_1 = a_2 = a_3 = a_4 = a_5 = 0$) through a bound testing approach after selecting the optimal lag length of lagged difference variables in Eq. 6, using Kripfganz and Schneider's (2019) critical values. After bound testing, long-run effects will be calculated by normalizing lag-level variables in Eq. 6, normalized by estimated a_1. Moreover, the short-run relationships will be corroborated in Eq. 7, if we can get a negative and statistically significant coefficient ∂. Then, short-run effects will be captured by coefficients of lagged difference variables in Eq. 7. At last, the asymmetries will be tested by applying the Wald test with H_0: equal coefficients of ORP_t and ORN_t.

Data analyses

Before moving to cointegration analyses, Ng and Perron unit root test is applied and the results are presented in Table 1. For conciseness, we report only MZa statistics. Results show that all variables, except Y_t and Y_t^2 with constant specification in Libya, are nonstationary at the level. Moreover, all series in all OPEC economies are stationary after the first difference. Hence, the order of integration is mixed in the Libya model, and it is one in the rest countries' models. Later, we apply ARDL cointegration, which is efficient in both cases of the mixed order and order one integration level.

After confirming the integration level, the cointegration test is applied to all countries' models in Table 2. The estimated F-value is higher than the critical value at 1% significance level in models of Algeria, Angola, Congo, Gabon, Libya, and Venezuela, and at 5% significance level in models of Equatorial Guinea and Iran, and at 10% in the UAE. Thus, the cointegration is verified in all the above-mentioned countries' models by the bound testing procedure. Moreover, the cointegration is alternatively verified in models of Saudi Arabia, Iraq, Kuwait, and Nigeria with the negative coefficient of ECT_{t-1}, which reflects the long-run converging equilibrium from any short-run fluctuations (Pesaran et al., 2001). In addition, the results of the diagnostic tests reflect the robustness of all estimated models. Therefore, we may proceed with long and short coefficients estimations.

In Table 3, we display the long-run coefficients from the selected ARDL models of all OPEC members. The EKC is corroborated with a positive coefficient of Y_t and a negative coefficient of Y_t^2 in models of Algeria, Congo, Gabon, Kuwait, and Saudi Arabia. Thus, the increasing income of these economies would increase emissions in the first phase of the EKC and might decrease emissions in the second phase of the EKC. Inquiring the natural resource rents and environmental quality, literature corroborated the EKC in resource-abundant economies (Baloch et al., 2019; Hassan et al., 2019; Tiba and Frikha, 2019; Shehzad et al., 2022). Likewise, Mahmood and Furqan (2021) have also validated this EKC in the spatial analysis of the GCC panel while investigating the connection between oil rents and emissions. Moreover, a U-shaped effect of income on CO_2 emissions is found in the model of Angola. So, the economic growth of Angola has a positive environmental effect with increasing economic growth in the first phase of the EKC. However, economic growth can have environmental consequences in the second phase of the EKC. This U-shaped relationship is also evident by Moutinho et al. (2020). For the rest

TABLE 1 Ng and Perron Test with MZa statistic.

		Level		First difference	
Country	Variable	C	C&T	C	C&T
Algeria	CO_t	-1.3809	-8.4282	-11.3874**	-22.5118**
	Y_t	0.6939	-2.8230	-12.0072**	-20.0690**
	Y_t^2	0.7124	-2.8376	-12.0387**	-20.0550**
	ORP_t	1.3011	-8.7704	-23.9670***	-23.7786**
	ORN_t	1.5209	-5.6560	-23.4621***	-23.7274**
Angola	CO_t	-5.7366	-10.2766	-16.6626***	-17.4922**
	Y_t	-5.5693	-6.7591	-13.0167**	-18.7113**
	Y_t^2	-5.4858	-6.6808	-12.7457**	-17.5224**
	ORP_t	1.0072	-6.7026	-18.5656***	-18.7858**
	ORN_t	1.5602	-7.8639	-18.7368***	-18.8113**
Congo	CO_t	-4.8377	-10.0163	-21.3311***	-21.3016**
	Y_t	-1.6946	-9.1150	-9.9109**	-17.6541**
	Y_t^2	-1.4955	-8.3502	-8.9654**	-17.8954**
	ORP_t	-0.0614	-3.7152	-21.1826***	-34.3458***
	ORN_t	1.4699	-11.3346	-21.2715***	-20.9760**
Equatorial Guinea	CO_t	-1.1271	-7.3027	-16.7375***	-19.7132**
	Y_t	-0.9059	-5.9031	-13.0360**	-18.4394**
	Y_t^2	-0.9303	-2.2983	-12.9772**	-17.9654**
	ORP_t	-4.4056	-5.7615	-18.2929***	-18.4821**
	ORN_t	1.8127	-2.3378	-18.7245***	-18.9996**
Gabon	CO_t	-1.3683	-5.4968	-11.4769**	-18.7940**
	Y_t	-3.2585	-5.0393	-10.2911**	-19.5874**
	Y_t^2	-3.4078	-5.2231	-10.5974**	-18.9367**
	ORP_t	1.2878	-8.8578	-23.9491***	-23.6118**
	ORN_t	1.5291	-11.9656	-23.7008***	-23.8830***
Iran	CO_t	0.6907	-4.6572	-22.8715***	-32.2228***
	Y_t	-4.6886	-5.5048	-18.0701***	-23.2094**
	Y_t^2	-4.7914	-5.6438	-17.8755***	-22.6115**
	ORP_t	1.4372	-11.2832	-23.9560***	-23.9455***
	ORN_t	1.6082	-10.9391	-23.9497***	-23.7297**
Iraq	CO_t	-6.1830	-8.1953	-23.5437***	-23.8404***
	Y_t	-0.8449	-16.9224*	-21.5134***	-21.4907**
	Y_t^2	-0.8151	-17.0471*	-21.5736***	-21.555**
	ORP_t	1.4646	-7.5783	-23.8669***	-23.9419***
	ORN_t	1.5482	-6.0789	-23.9542***	-23.9621***
Kuwait	CO_t	-7.8008	-9.4091	-23.7799***	-23.7556**
	Y_t	-0.6260	-6.6958	-22.8345***	-23.5927**
	Y_t^2	-0.6589	-10.8454	-23.0133***	-23.5706**
	ORP_t	1.4461	-9.4349	-23.6243***	-23.8452***
	ORN_t	1.2833	-9.5863	-23.9560***	-23.8601***
Libya	CO_t	-4.3285	-9.8957	-11.4117**	-19.0991**
	Y_t	-9.7188**	-10.0247	-13.5100**	-18.6321**
	Y_t^2	-9.7174**	-10.0473	-13.4185**	-17.9647**
	ORP_t	1.4786	-7.8150	-13.5200**	-20.9727**
	ORN_t	1.7802	-3.4898	-12.6268**	-18.8745**
Nigeria	CO_t	-5.4910	-6.9321	-10.1093**	-23.1954**

(Continued on following page)

TABLE 1 (*Continued*) Ng and Perron Test with MZa statistic.

Country	Variable	Level		First difference	
		C	C&T	C	C&T
	Y_t	-1.9957	-2.9388	-9.4014**	-17.9654**
	Y_t^2	-1.9233	-2.8934	-8.9654**	-18.6354**
	ORP_t	1.0629	-5.6764	-23.8407***	-23.3055**
	ORN_t	0.9764	-12.8425	-22.7824***	-23.1909**
Saudi Arabia	CO_t	-1.9908	-9.0986	-11.6223**	-22.9249**
	Y_t	-5.2437	-11.9959	-8.1625**	-18.3824**
	Y_t^2	-5.0723	-11.7556	-8.3970**	-17.6909**
	ORP_t	1.2537	-7.7863	-23.9489***	-23.8570***
	ORN_t	1.3615	-5.2282	-23.4081***	-23.6525**
UAE	CO_t	0.4304	-10.6527	-21.3097***	-22.6857**
	Y_t	-0.6444	-10.4573	-19.3544***	-19.5315**
	Y_t^2	-0.6093	-10.1683	-19.5500***	-19.7233**
	ORP_t	1.1607	-11.1494	-21.4579***	-21.2794**
	ORN_t	1.2887	-3.5790	-20.4277***	-20.8410**
Venezuela	CO_t	-0.8808	-4.6379	-10.6203**	-19.5904**
	Y_t	-4.6790	-11.2927	-20.3495***	-20.6164**
	Y_t^2	-4.6219	-11.2526	-20.2987***	-20.5447**
	ORP_t	1.1989	-10.2679	-21.3852***	-21.1842**
	ORN_t	1.6373	-10.1268	-21.3162***	-21.2273**

Note: ** and *** shows stationarity at 1% and 5% significance level. C is constant and T is the time trend.

TABLE 2 Cointegration analyses.

Country	F-statistics	Heteroscedasticity test	Serial correlation test	Normality test	Functional form test
Algeria	7.7323	1.8907 (0.1160)	0.0241 (0.9762)	0.9121 (0.6254)	2.1499 (0.1295)
Angola	10.3219	0.4145 (0.9165)	0.2712 (0.7646)	2.4563 (0.1287)	1.8051 (0.4055)
Congo	5.0707	1.8926 (0.1089)	0.4691 (0.6296)	1.3652 (0.5126)	0.0465 (0.8305)
Equatorial guinea	4.2903	1.4505 (0.2325)	2.2432 (0.1231)	2.6451 (0.2064)	1.1423 (0.2932)
Gabon	6.3257	0.2334 (0.9179)	0.8798 (0.4225)	0.6487 (0.7354)	2.5292 (0.1193)
Iran	4.9363	1.1746 (0.3373)	0.3514 (0.6974)	1.4171 (0.4269)	1.5252 (0.2051)
Iraq	2.0715	0.1443 (0.9807)	2.3063 (0.1124)	1.2607 (0.5052)	2.2019 (0.1235)
Kuwait	2.5061	0.6082 (0.6941)	0.4007 (0.6725)	0.9312 (0.6254)	2.6337 (0.1024)
Libya	7.5673	1.1123 (0.4026)	2.0403 (0.1441)	0.8497 (0.6539)	0.1011 (0.7544)
Nigeria	1.9768	1.5026 (0.1879)	0.0471 (0.9540)	1.2166 (0.5248)	0.8449 (0.4034)
Saudi Arabia	1.6680	0.6729 (0.7280)	0.8297 (0.4448)	3.7104 (0.1325)	0.3995 (0.5312)
UAE	3.8263	0.5241 (0.7862)	0.0591 (0.7427)	1.3725 (0.4875)	0.0134 (0.9086)
Venezuela	5.7948	0.3993 (0.8747)	0.9291 (0.4044)	0.3520 (0.8386)	0.0475 (0.8287)
Critical F-values					
	Lower bound	Upper bound			
1 percent	3.7410	5.0052			
5 percent	2.8601	3.9917			
10 percent	2.4460	3.5052			

() carries *p*-values.

TABLE 3 The long run results.

Country	Variable	Coefficient (p-value)	Country	Variable	Coefficient (p-value)
Algeria	Y_t	27.3521 (0.0445)	Kuwait	Y_t	2.9929 (0.6651)
	Y_t^2	-1.6111 (0.0529)		Y_t^2	-0.1779 (0.6123)
	ORP_t	-0.0113 (0.0289)		ORP_t	0.0274 (0.0373)
	ORN_t	-0.0126 (0.0029)		ORN_t	0.0190 (0.1081)
	Intercept	-114.8050 (0.0392)		Intercept	-10.0804 (0.7667)
Angola	Y_t	-41.5477 (0.0001)	Libya	Y_t	0.5790 (0.6570)
	Y_t^2	2.6917 (0.0001)		Y_t^2	-0.0336 (0.6447)
	ORP_t	0.0057 (0.0203)		ORP_t	0.0015 (0.0167)
	ORN_t	0.0026 (0.3277)		ORN_t	0.0023 (0.0003)
	Intercept	159.4128 (0.0001)		Intercept	-0.2810 (0.9614)
Congo	Y_t	25.6642 (0.0011)	Nigeria	Y_t	53.5696 (0.2454)
	Y_t^2	-1.9610 (0.0020)		Y_t^2	-3.5214 (0.2528)
	ORP_t	0.2422 (0.0169)		ORP_t	-0.0303 (0.0812)
	ORN_t	0.1199 (0.1938)		ORN_t	-0.0277 (0.1137)
	Intercept	-85.1945 (0.0004)		Intercept	-203.5100 (0.2383)
Equatorial Guinea	Y_t	0.7763 (0.7601)	Saudi Arabia	Y_t	8.9657 (0.0827)
	Y_t^2	-0.0187 (0.8961)		Y_t^2	-0.4405 (0.0879)
	ORP_t	0.0472 (0.0149)		ORP_t	0.0061 (0.0003)
	ORN_t	0.0242 (0.0103)		ORN_t	0.0035 (0.0450)
	Intercept	-6.0418 (0.5607)		Intercept	-43.2632 (0.0934)
Gabon	Y_t	22.2687 (0.0812)	UAE	Y_t	2.0032 (0.7319)
	Y_t^2	-1.1545 (0.0891)		Y_t^2	-0.1062 (0.6902)
	ORP_t	-0.0020 (0.5152)		ORP_t	-0.0160 (0.0262)
	ORN_t	0.0048 (0.1428)		ORN_t	-0.0018 (0.7158)
	Intercept	-104.9890 (0.0801)		Intercept	-5.0907 (0.8739)
Iran	Y_t	-1.8149 (0.7296)	Venezuela	Y_t	7.3054 (0.4706)
	Y_t^2	0.1397 (0.6443)		Y_t^2	-0.4062 (0.4468)
	ORP_t	0.0085 (0.0005)		ORP_t	0.0002 (0.8354)
	ORN_t	-0.0017 (0.4569)		ORN_t	-0.0017 (0.1034)
	Intercept	6.1739 (0.7860)		Intercept	-31.0972 (0.5170)
Iraq	Y_t	-6.6515 (0.2463)			
	Y_t^2	0.4103 (0.2619)			
	ORP_t	0.0057 (0.0602)			
	ORN_t	0.0017 (0.4923)			
	Intercept	27.7532 (0.2177)			

of the OPEC economies, our results show that economic growth did not have any effect on CO_2 emissions.

In the oil rents and CO_2 emissions relationship, increasing oil rents (ORP_t) show a positive effect on emissions in the models of Equatorial Guinea, Iran, Iraq, Angola, Congo, Kuwait, Libya, and Saudi Arabia. It means that increasing oil rents are increasing economic activities, which need energy and pollute the environment of these countries. Thus, the scale effect of oil rents is dominant in these countries and increasing oil rents have environmental consequences in 8 out of 13 analyzed OPEC members. Many past studies have confirmed that natural resource rents accelerated carbon emissions (Bekun et al., 2019; Adediyan et al., 2020; Hussain et al., 2020; Ulucak and Khan, 2020; Wang et al., 2020; Agboola et al., 2021; Nwani and Adams, 2021; Onifade et al., 2021; Huang and Guo, 2022). Moreover, the literature has corroborated the positive effect of resource rents on the ecological footprint (Baloch et al., 2019; Hassan et al., 2019; Jahanger et al., 2022). Mahmood and Furqan (2021) corroborated a positive connection between oil rents and emissions in the GCC panel's spatial analysis. On the other hand, our results also show that increasing oil rents decrease emissions in Algeria, the UAE, and Nigeria. Thus, the technique and

TABLE 4 The short run results.

Country	Variable	Coefficient (p-value)	Country	Variable	Coefficient (p-value)
Algeria	ΔY_t	17.7486 (0.0874)	Kuwait	ΔY_t	0.9144 (0.4891)
	ΔY_t^2	-1.0454 (0.0980)		ΔY_t^2	-0.0544 (0.4222)
	ΔORP_t	-0.0073 (0.0153)		ΔORP_t	0.0084 (0.0661)
	ΔORN_t	-0.0082 (0.0028)		ΔORN_t	0.0058 (0.1081)
	ECT_{t-1}	-0.6489 (0.0000)		ECT_{t-1}	-0.3055 (0.0002)
Angola	ΔY_t	-58.4966 (0.0012)	Libya	ΔY_t	2.0880 (0.1829)
	ΔY_{t-1}	47.3092 (0.0447)		ΔY_{t-1}	4.3813 (0.0079)
	ΔY_t^2	3.8820 (0.0010)		ΔY_t^2	-0.1238 (0.1616)
	ΔY_{t-1}^2	-2.9607 (0.0059)		ΔY_{t-1}^2	-0.2552 (0.0064)
	ΔORP_t	0.0071 (0.0199)		ΔORP_t	0.0017 (0.2757)
	ΔORN_t	0.0033 (0.3213)		ΔORN_t	0.0026 (0.1040)
	ECT_{t-1}	-0.2595 (0.0000)		ECT_{t-1}	-0.6453 (0.0000)
Congo	ΔCO_{t-1}	0.3480 (0.0153)			
	ΔY_t	23.4251 (0.0063)	Nigeria	ΔY_t	16.1860 (0.0004)
	ΔY_t^2	-1.7899 (0.0087)		ΔY_t^2	-0.6622 (0.1255)
	ΔORP_t	0.2211 (0.0190)		ΔORP_t	0.0054 (0.3121)
	ΔORN_t	0.1095 (0.1893)		ΔORN_t	-0.0079 (0.0911)
	ECT_{t-1}	-0.9128 (0.0000)		ECT_{t-1}	-0.2838 (0.0007)
Equatorial Guinea	ΔY_t	0.1934 (0.9179)	Saudi Arabia	ΔY_t	-6.2140 (0.2580)
	ΔY_t^2	-0.0047 (0.9650)		ΔY_t^2	0.3416 (0.2096)
	ΔORP_t	0.0117 (0.3785)		ΔORP_t	0.0020 (0.1706)
	ΔORN_t	0.0060 (0.2693)		ΔORN_t	-0.0040 (0.0593)
				ΔORN_{t-1}	-0.0035 (0.0881)
	ECT_{t-1}	-0.2491 (0.0000)		ECT_{t-1}	-0.3287 (0.0018)
Gabon	ΔY_t	11.6923 (0.1402)	UAE	ΔY_t	1.6069 (0.0000)
	ΔY_t^2	-0.6062 (0.1478)		ΔY_t^2	-0.0550 (0.6914)
	ΔORP_t	-0.0010 (0.5076)		ΔORP_t	-0.0083 (0.0143)
	ΔORN_t	0.0025 (0.0018)		ΔORN_t	-0.0009 (0.7072)
	ECT_{t-1}	-0.5251 (0.0000)		ECT_{t-1}	-0.5177 (0.0000)
Iran	ΔY_t	-1.1174 (0.7242)	Venezuela	ΔY_t	5.4178 (0.0000)
	ΔY_t^2	0.0860 (0.6354)		ΔY_t^2	-0.3349 (0.7015)
	ΔORP_t	0.0052 (0.0069)		ΔORP_t	0.0002 (0.9165)
	ΔORN_t	-0.0011 (0.4520)		ΔORN_t	-0.0014 (0.4022)
	ECT_{t-1}	-0.6157 (0.0000)		ECT_{t-1}	-0.8245 (0.0000)
Iraq	ΔY_t	-2.7154 (0.2433)			
	ΔY_t^2	0.1675 (0.2532)			
	ΔORP_t	0.0023 (0.1706)			
	ΔORN_t	0.0007 (0.6499)			
	ECT_{t-1}	-0.4082 (0.0006)			

composition effects of oil rents are dominant over the scale effect in these three countries, which may help to reduce the CO_2 emissions in these economies. Some studies have also corroborated the negative impact of resource rents on emissions (Balsalobre-Lorente et al., 2018; Liu et al., 2022) and on the ecological footprint (Zafar et al., 2019; Danish and Khan, 2020; Danish and Khan, 2020; Kongbuamai et al., 2020; Ulucak and Khan, 2020). Moreover, Ozturk (2017) corroborated the negative impact of oil rents on emissions in Latin America. Furthermore, decreasing oil rents (ORN_t) reduce emissions in models of Saudi Arabia, Angola, Equatorial Guinea, and Libya. So, the decreasing oil rents are decreasing economic activities in these four economies, which would reduce CO_2 emissions. Hence, decreasing oil rents would reduce environmental consequences in 4 out of 13 OPEC economies and lesser dependence on oil rents has pleasant environmental effects in these economies. However, decreasing oil rents have a negative effect on CO_2 emissions in Algeria.

In the long-run asymmetry analyses, the asymmetry in the relationship between oil rents and CO_2 emissions is substantiated by the statistically significant effect of ORP_t and statistically insignificant effect of ORN_t in the models of Angola, Congo, Iran, Iraq, Kuwait, Nigeria, and the UAE. Besides, the impacts of ORP_t and ORN_t are insignificant in Gabon and Venezuela. For the rest cases, the Wald test is employed, and F-stat (*p*-value) is found as 0.2861(0.4451), 3.2145(0.0841), 0.4263(0.2764), and 4.1257 (0.0461) in Algeria, Equatorial Guinea, Libya, and Saudi Arabia, respectively. Thus, the symmetrical impact of oil rents is corroborated in Algeria and Libya. However, asymmetry is validated in Equatorial Guinea and Saudi Arabia.

Table 4 shows that the short-run relationships have been validated by a negative coefficient of ECT_{t-1} in all estimated models with different speeds of adjustments. Moreover, the EKC is corroborated with a positive parameter of ΔY_t and negative coefficient of $\Delta {Y_t}^2$ in the models of Algeria and Congo, and with a positive parameter of ΔY_{t-1} and negative coefficient of $\Delta {Y_{t-1}}^2$ in a model of Libya with 1 year lag. A U-shaped impact of growth on emissions is substantiated in the model of Angola and a positive monotonic impact of growth on emissions is observed in Nigeria, the UAE, and Venezuela. Increasing oil rents (ΔORP_t) carry a positive impact on emissions in the models of Angola, Congo, Iran, and Kuwait and have a negative effect in the case of Algeria and the UAE. Thus, increasing oil rents are increasing economic activities and CO_2 emissions in Angola, Congo, Iran, and Kuwait in the short run, and have environmental consequences in 4 out of 13 analyzed OPEC economies. However, increasing oil rents reduce CO_2 emissions in 2 out of 13 analyzed countries. Moreover, decreasing oil rents (ΔORN_t) carry a negative impact on emissions in Algeria, Gabon, Nigeria, and Saudi Arabia.

In the short-run asymmetry analyses, asymmetry is substantiated by the statistically significant effect of ΔORP_t and the statistically insignificant effect of ΔORN_t in the models of Kuwait, the UAE, Angola, Congo, and Iran. Moreover, asymmetry is substantiated by the statistically significant effect of ΔORN_t and the statistically insignificant effect of ΔORP_t in the models of Gabon, Nigeria, and Saudi Arabia. In addition, the effects of both ΔORP_t and ΔORN_t are found statistically insignificant in Equatorial Guinea, Iraq, Libya, and Venezuela. Furthermore, the Wald test is applied, and F-stat (*p*-value) is found 0.1648 (0.7025) in Algeria. Hence, symmetry is corroborated.

Conclusion

Oil rents might be responsible for pollution emissions in oil-abundant economies. The present study probes the asymmetrical impact of oil rents on CO_2 emissions in 13 OPEC economies and also tests the EKC hypothesis using the period 1970–2019. The EKC is proven in 5 out of 13 economies in long run, i.e., Algeria, Congo, Gabon, Kuwait, and Saudi Arabia. Thus, the technique and composition effects of economic growth may outweigh the scale effects in the long run after a threshold point in these economies. However, a U-shaped relationship is found in Angola in both the long and short run. In the short run, the EKC is corroborated in Algeria, Congo, and Libya and economic growth carries a monotonic positive impact on emissions in Nigeria, the UAE, and Venezuela. Increasing oil rents raise CO_2 emissions in 8 out of 13 OPEC economies in the long run, i.e., Equatorial Guinea, Iran, Iraq, Angola, Congo, Kuwait, Libya, and Saudi Arabia. Hence, the scale effects of increasing oil rents are dominant over the technique and composition effects and increasing oil rents has environmental consequences in these economies. In contrast, increasing oil rents reduce emissions in the UAE, Algeria, and Nigeria. Thus, increasing oil rents have pleasant long-run environmental effects in reducing CO_2 emissions in 3 out of 13 analyzed countries, which reflects that technique and composition effects are dominant over scale effects in these economies. Decreasing oil rents help to reduce CO_2 emissions in Angola, Equatorial Guinea, Libya, and Saudi Arabia and increase emissions in Algeria. Moreover, asymmetrical long-run effects of oil rents on CO_2 emissions are found in Saudi Arabia, the UAE, Angola, Congo, Iran, Iraq, Kuwait, Nigeria, and Equatorial Guinea. Increasing oil rents have a positive effect on emissions in Angola, Congo, Iran, and Kuwait and carry a negative impact in Algeria and the UAE in the short run. Besides, falling oil rents increase emissions in Algeria, Gabon, Nigeria, and Saudi Arabia. Moreover, asymmetrical short-run impacts of oil rents are validated in Angola, Congo, Iran, Kuwait, the UAE, Gabon, Nigeria, and Saudi Arabia.

Based on long-run results, we recommend Equatorial Guinea, Angola, Congo, Saudi Arabia, Iran, Iraq, Kuwait, and Libya to invest their oil rents in the development of green and renewable energy projects, avoiding the negative ecological effects of oil rents. Moreover, the over-dependence of these economies on the oil sector may also be one of the reasons for environmental problems. Thus, the economies should diversify from the oil sector by investing the oil rents in the non-oil sector of the economies to avoid the Dutch Disease phenomenon in OPEC economies. Now-a-day, oil prices and rents are booming in OPEC economies, and it is the right time to invest the excessive oil rents to condemn pollution by using these rents in renewable and green projects and by investing in diversification policy. Moreover, increasing oil rents helped reduce emissions in the UAE, Algeria, and Nigeria and these countries should further focus on renewable projects to support a sustainable environment to a greater extent.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://databank.worldbank.org/reports.aspx?source=world-development-indicators.

Author contributions

HM: Writing Original Draft preparation, Methodology, Software, Literature Review. NS: Data Curation, Writing, Reviewing and Editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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