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ARTICLE

Economic and environmental implications of resource rent: A dual analysis of Venezuela's sustainability

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Abstract

Venezuela is among the several countries of the world endowed with natural resources such as oil rent and others. The influence of these resources, which can be felt in both economic and environmental development, is capable of impacting sustainable development goals of any country rich in them. Considering the global climate goals, it is essential to investigate the impact of natural resource rent on its sustainable development goals. We applied Venezuelan country-specific data of 1972–2014 for an insightful study of the country's sustainable development amidst high resource rent with regard to both economic and environmental performance. The principles of the environmental Kuznets curve (EKC) and pollution haven and halo hypothesis (PHH) were considered to ascertain the pattern and effect of the economic growth and foreign direct investment (FDI) on Venezuelan environmental performance. Different methods such as the autoregressive distributed lag (ARDL) dynamics and bounds, structural break, and Granger causality test were applied for an accurate estimation and insightful analysis. From the ARDL estimations, we found an N-shaped Kuznets curve, which counters the U-shaped Kuznets, for the case of Venezuela. Both natural resources and FDI are found to impact positively on the environment, and this confirmed the pollution halo hypothesis for Venezuela. Fossil fuel energy source is found to impact negatively Venezuela's environment with positive relationship between energy use and CO2. From the Granger causality finding, a unidirectional Granger causality is found to transmit from FDI to environment, while bidirectional Granger causality is found to transmit between economic growth and environment. With the findings from both analyses, especially from the vector error correction model (VECM) Granger causality, a nexus is established

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among economic growth, environment, and FDI, which confirmed the pollution halo hypothesis.

1 | INTRODUCTION

Resource rents in countries with high natural resource endowment significantly affect economic and environmental factors. In cases where the share of resource rents in the country's total exports and gross domestic product (GDP) is high, the dependence of the economy on resources increases. In these countries, natural resource rents come to the fore as the main factor that triggers economic growth and an increase in investments (Hassan et al., 2019). In this context, examining the effects of resource rent dependency on economic growth and the environment has a critical importance for sustainable development.

The production and consumption of non-renewable energy sources cause environmental degradation by increasing carbon emissions (Wang et al., 2011; Adedoyin et al., 2020). CO2, which is produced by the combustion of primary fossil fuels such as oil, natural gas, and coal, accumulates in the atmosphere. High CO2 emissions worsen environmental performance by causing global warming and climate change (Sweeney, 2000). Worsening environmental pollution has made it urgent to take on responsibility at the national and global scale.

In addition to their direct impact via CO2 emissions, natural resources have an indirect impact on the environmental performance of a country through economic growth (Shahbaz, Tiwari, and Nasir, 2013). The relationship between economic growth and environmental degradation is widely explained in the literature by means of the environmental Kuznets curve (EKC). According to the hypothesis in question, economic growth initially triggers environmental degradation, but it begins to improve environmental quality after a certain point (Dasgupta et al., 2002). On the other hand, resource rents can play an encouraging role in commercial and financial liberalization and can lead to economic growth. There is an increase in investments between countries with the expansion of economic liberalization. In this context, the EKC effect has provided an opportunity to examine the impacts of foreign direct investment (FDI) on environmental factors moving from developed countries towards developing countries (Cole, 2004). Due to the differences in environmental regulations between northern and southern countries, investments flow from northern countries, which apply strict environmental regulations, to southern countries, which implement lax environmental regulations. Southern countries accept the investment flow in order to specialize in these polluting sectors and gain comparative advantage as a result. If environmental factors are negatively affected in a developing country, where there is FDI, this situation is explained by the pollution haven hypothesis (Cole, 2004). On the other hand, if FDI affects the economic and environmental performance of the country positively, the pollution halo hypothesis is valid (Zarsky, 1999). The strong relationship between economic growth and environmental performance can be examined with trade openness, FDI, and CO2 emissions. In this context, these factors will be used in this study in order to examine the effects of natural resource endowment in Venezuela.

Venezuela has rich oil and natural gas reserves. It has been a country with the highest share in proven crude oil reserves in the world since 2010, and it maintains this advantage with 303.81 billion barrels in 2019 (OPEC, 2020). Venezuela is also ranked as fifth among the Organization of Petroleum Exporting Countries (OPEC) countries in natural gas reserves. By the year 2019, natural gas reserves were 5,674 bn standard cubic meters (OPEC, 2020). However, the production and exportation of natural gas are not as high as those of oil. In 2019, the oil export was US$22,491.84 million, and it was 95% of total exports. In the same year, the ratio of revenues from oil exports to GDP was 31.9% (OPEC, 2020). As these figures indicate, oil resources are the main driving force of economic growth in Venezuela. In a country where the economy is so dependent on resource revenues, it has become

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necessary to examine the impacts of natural resource endowment on economic and environmental performance over the years.

On the other hand, the role of resource rents in the economic liberalization process is an important factor explaining the change in both economic and environmental performance. The natural resources sector, which was dominated by the national oil company "Petroleos de Venezuela S.A. (PDVSA)" in the 1970s and 1980s, has adapted to the increasing international economic integration in the 1990s (Giusti, 1999; Hidalgo, 2007). Foreign investments were introduced for the liberalization of the oil industry, but in 1998, the effects of foreign company investments on the industry were reduced within the framework of the policies of the Chavez government (Gott, 2008). The trade openness and FDI inflows vary in certain periods due to the changing foreign economic policies of Venezuela over the years.

The high level of resource exports and the variability of FDI inflows over the years in Venezuela, a country so dependent on natural resource rent, have necessitated conducting an empirical analysis of the effects of the endowment on economic growth and environmental conditions. Therefore, the study focused on determining the role of the trio of natural resource rent, economic growth, and FDI on environmental quality in a country exposed to high economic activities and with high natural resource rent capable of impacting the environmental performance. It is aimed to contribute to the determination of effective policies by revealing how these factors affect environmental performance with supporting evidences. For a holistic and in-depth study, we applied some scientific approaches such as descriptive statistics, stationarity and structural break tests, cointegration, and dynamic estimate with autoregressive distributed lag (ARDL). Also, Granger causality with some diagnostic tests is adopted for robust and accurate empirical findings and analysis. The theoretical emphasis is on the EKC and PHH. Literature has always focused on either EKC or PHH for analysis that seeks to infer the contributing roles of economic growth and FDI in environmental sustainability. We adopt both hypotheses to unveil the link between FDI and economic growth in determining the EKC for Venezuela. FDI contributes to the economic growth of the host country; hence, the way and manner in which foreign investors perform their economic activities will manifest in the nature of EKC obtained in such a country. This will close the gap in the literature that depends only on EKC or PHH in determining the environmental sustainability of Venezuela. As environmental sustainability is a global issue that is beyond national borders, studying environmental impacts has both national and international importance and implications. The findings from this study will have implication to some of the neighbouring countries with similar economic features such as Panama, Ecuador, and Brazil.

Hence, this study is posed to add to the literature by attempting to answer the following questions with regard to economic and environmental implications of the rich resource rent in Venezuela: (a) Are there environmental consequences of natural resource rent for the case of Venezuela? (b) Are there environmental consequences of openness (FDI) for the case of Venezuela? (c) Are there prospects for sustainable development in view for the case of Venezuela? No doubt, there is existing literature in the same topic, but our study is unique from other studies in this area with the application of total resources inclusive of other natural resources in Venezuela and FDI. Also, examining both the EKC and PHH in the country is expected to help explain similar possible implications for other economies that are also dependent on natural resource revenues.

Many scholars have contributed to the literature to explain the roots of this matter; they are included in the literature review, which is presented in the Sections 2 and 3 of this study. Sections 4, 5, and 6 present data and methodology, empirical results and discussion, and conclusion and policy suggestions, respectively.

2 | THEORETICAL BACKGROUND

Two approaches have been adopted while examining the effects of high resource rents on economic and environmental performance in evaluating the sustainable development process of Venezuela. The

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theoretical framework of this study was formed with the EKC in order to analyse the relationship between economic growth and environmental pollution. On the other hand, the environmental effects of economic liberalization have been examined within the scope of PHH by introducing the relationship between FDI and CO2 emissions. These two theoretical beacons (EKC and PHH) of our study have been studied differently by some other scholars without much emphasis on the link between the two theories in determining sustainable development of any economy. Hence, it is adopted in this study to unveil the effect of FDI in ascertaining the EKC for the case of Venezuela. The EKC hypothesis tends to monitor the interaction between economic growth and environmental performance. Foreign investors contribute to the economic growth of the host countries through investing in the existing companies or by establishment of their companies in the host countries. Hence, FDI is seen as one of the contributing factors to the economic growth. This means that the way and the manner in which foreign investors practice their economic activities will definitely reflect in the way the economic growth impacts the environment. This is accommodated in this current study by applying both EKC and PHH. While explaining the relationship between income per capita and income distribution inequality, the Kuznets curve states that increasing income per capita negatively affects the income distribution inequality in the early stages, but the income distribution would become fairer as the income per capita continues to increase (Kuznets, 1955). As the inverse U-shaped relationship between environmental degradation and economic growth is parallel to the relationship that Kuznets establishes between per capita income and income distribution, it is referred to as the EKC (Panayotou, 2000). The EKC hypothesis establishes the inverse U-shaped relationship between per capita income and environmental pollution, explaining that environmental pollution increases in the first phase of economic growth, and then it decreases after the point where economic growth exceeds a certain level (Cole, Rayner, and Bates, 1997; Stern, 2004; Dinda, 2004; Saboori, Sulaiman, and Mohd, 2012; Udemba, 2020). The impacts of openness with regard to FDI and trade on environmental factors by increasing the scale of economic activities have led to several studies on this subject (Grossman and Krueger, 1991). The environmental effects of openness are scale, technique, and composition effects. The increase in economic growth with the increase of openness is explained by the effect of scale, and at this stage, economic growth is focused on without taking any environmental regulations into account. While other conditions are constant, there is environmental degradation as a possible consequence of the scale effect. In technical effect, a further level of scale effect is defined together with the technological progress. At this stage, procedures including environmental regulations are preferred to use in production methods. In the composition effect, there is full awareness of the harmony of economic and environmental factors. With advanced technology, economic and environmental sustainability efforts are increased (Cole and Elliott, 2003).

3 | LITERATURE REVIEW

Several studies on the EKC and pollution haven hypotheses in the literature have sought explanations for how natural resources affect the development of environmental sustainability through economic growth. Robalino-López et al. (2015) analysed the 1980–2025 period of Venezuela with the EKC by taking account of both the data of the past years and the projections for the future years. The results of the analysis revealed that the EKC hypothesis is not valid, but environmental stability is likely to be achieved in the medium term. Renewable energy sources were referred to in order to ensure environmental improvement. Bekun, Alola, and Sarkodie (2019) analysed the relationship between resource rent, economic growth, and CO2 emissions in 16 EU countries for the years between 1996 and 2014 with the pooled mean group (PMG)-ARDL model. The findings of the study revealed a long-term positive relationship between resource rent and CO2 emissions. It was stated that economic growth and non-renewable energy consumption increase CO2 emissions and affect environmental performance negatively. In another study with similar results, it was argued that resource abundance in countries rich in natural resources causes environmental degradation and poses a serious threat to

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sustainability. It was determined that globalization plays an important role in recovering from this disruptive effect (Erdoğan et al., 2020).

Shahbaz et al. (2020), in a study in which they examined the relationship between economic growth and CO2 emissions with China's data of 1984–2018, determined that there is an inverted U-shaped relationship between the variables and confirmed the validity of the EKC hypothesis. Usman, Iorember, and Olanipekun (2019) stated the existence of the EKC hypothesis in India. In addition, it was explained that energy consumption reduces environmental quality both in the short and long term.

Kassouri, Altınbaş, and Bilgili (2020), in their study in which they examined the relationship between oil price fluctuations and financial development in oil exporting countries, used panel data analysis for 21 oil-exporting countries for the years between 1984 and 2016. The importance of democratic institutions was emphasized because of the fact that oil price fluctuations, which may hinder financial development, may affect these countries negatively.

In another study considering the 1971–2014 period of South Africa, it was argued that energy consumption and globalization affect environmental performance negatively. It was found that in the long run, economic growth causes environmental degradation (Usman et al., 2020). When Pakistan's environmental performance was analysed for the years between 1972 and 2016, it was concluded that the main factor causing CO2 emissions is economic development (Yasmeen et al., 2019).

In addition to studies discussing the effects of resource rent, energy consumption, and economic growth on environmental factors, there are many studies in the literature that are examining CO2 emissions in the context of FDI. Lucas, Wheeler, and Hettige (1992) confirmed the pollution haven hypothesis in their studies, in which they examined pollution sectors between developing countries and developed countries for the years between 1960 and 1988. Mani and Wheeler (1997) concluded that between 1960 and 1995, the sectors that caused pollution increased in developing countries and decreased in OECD countries. Furthermore, in their study Cole, Elliott, and Zhang (2011) examined the link between economic growth and industrial emissions by using data from key urban areas of China between 2001 and 2004. It was shown that air and water pollution increase with economic growth. Hoffmann et al. (2005), studied the relationship between FDI and pollution by using the Granger causality test for 15 to 28 years in 112 countries. They reached results supporting the pollution haven hypothesis and detected a causality relationship between the two variables depending on the development level of the country.

Acharyya (2009), in his study considering India for the period of 1980–2003, found that FDI has an impact on economic growth, and there is a significant relationship between FDI and pollution. Mutafoğlu (2012) examined the relationship between FDI, economic growth, and CO2 emissions in Turkey for the period of 1987–2009. As a result of the cointegration test and the Granger causality test, he found a relationship between these variables. The pollution haven hypothesis is verified. Zheng and Shi (2017), in the study on China for the period 2004–2013, showed that the validity of the pollution haven hypothesis is related to the type of environmental policy carried out as well as industrial characteristics.

Murthy and Gambhir (2018) confirmed the validity of EKC and PHH in India for the period 1994–2014. In their study, Sarkodie and Strezov (2019) concluded that the pollution haven hypothesis is valid, finding that there is a positive relationship between the CO2 emissions and energy use in emerging economies such as China, India, Indonesia, Iran, and South Africa. In another study, it was confirmed that export-driven growth causes environmental pollution (Valadez and Hu, 2016). Udemba, Güngör, and Bekun (2019), in their study in which they used data of Indonesia for the period 1980–2017, concluded that FDI inflows increase economic growth, affect the energy consumption of the country, and reduce carbon emissions. They confirmed the pollution halo hypothesis for Indonesia.

Yıldırım, Destek, and Özsoy (2017), in their study in which they tested the validity of PHH for Turkey for the period of 1974–2013, reached the conclusion that the increased GDP and energy consumption result in an increase in environmental pollution. They argued that FDI increases CO2 emissions until a certain level but reduces CO2 emissions after this certain level. Lopez et al. (2018),

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in their study in which they examined the relationship between trade openness and pollution for seven regions for the period of 1995–2009, concluded that trade openness reduces CO2 emissions in comparison with the hypothetical situation without international trade. It was concluded that the pollution haven hypothesis for China across regions is valid. Waqih et al. (2019), in the study in which they analysed the relationship between FDI and CO2 emissions in the SAARC region for the years 1986–2014 with the ARDL and fully modified ordinary least squares (FMOLS) models, found that the pollution haven hypothesis is valid in the short term.

Tobey (1990), by using the Hecksher–Ohlin–Vanek (HOV) cross-section dependency model, concluded that strict environmental policies implemented into polluting sectors are not measurably effective. In his study, Lee (2013) found a negative relationship between economic growth and CO2 emissions in G20 countries. Also, Şahinöz and Fotourehchi (2014) studied the PHH in Turkey for the period of 1974–2011. They stated that FDI reduces CO2 emissions compared with other factors, and the pollution haven hypothesis is not valid. Lacheheb, Abdul Rahim, and Sirag (2015) discussed the effects of income, population, and fuel consumption on environmental performance. In their study, in which they used the ARDL model, they found that the EKC hypothesis is not valid in Algeria. The findings of the study showed that the use of non-renewable energy should be reduced and renewable energy sources should be turned to for sustainable development.

4 | DATA, METHODOLOGY, AND MODELLING

Country-specific data of Venezuela that span from 1980 to 2014 are applied in this study. The choice of the variables and the period is dependent on the availability of data. Because of the limitation and unavailability of some of Venezuela's data (especially for natural resources), the authors decided to limit their period to the available year (2014). Considering the forecasting nature of this study, the limitation posed by the sample year of 2014 was sorted out when inference could be made from the possibility of long-run interactions among the variables. Also, findings from Granger could be used for forecasting and inference that are capable of covering the vacuum. Following the intent of the authors, the following variables were adopted for effective and insightful analysis: real GDP per capita (constant, 2010 US$), FDI, net inflow (%GDP), total natural resources (TNR; %GDP), energy use, (kg of oil equivalent per capita), and carbon dioxide emission (CO2 emissions measured in metric tons per capita). Also, squared real GDP per capita (constant, 2010 US$) was applied in this analysis for the purpose of ascertaining the presence of an EKC. All the variables were obtained from World Bank Development Indicators, 2018 and are all in logarithm form except the FDI and TNR rent that are already expressed in percentage form. The summary of the data with respect to the definition of the variables is presented in Table 1.

Methods adopted in this research are statistics summary, test of stationarity, optimal lag selection, test of cointegration (with both bound and Johansen for robustness check), and empirical investigation in the linear and dynamic approaches. Granger causality analysis is applied equally among the methods in this study.

Summary statistics was considered the best method of testing the normal distribution and conformity of the data to the linear and dynamic approaches. This was measured with the outputs of the Jarque–Bera, skewness, and kurtosis tests. Stationarity test was done to ascertain the stationarity and integral form of the series. The variables could either be stationary at level or at first difference, or even in mixed order, and this determined the order of integration of the series (i.e., I (0), I (1), or mixed). Both traditional methods (Dickey Fuller, 1979 and Perron, 1990) of testing for unit root and the Zivot–Andrews (1992) structural break test were all applied for valid and justified findings on the movement of the data. Traditional methods of estimating may be able to uncover the effect of structural break on the variable and may sometimes account for such a break as unit root; in this case, it is always good to apply structural break as a robust check to the traditional unit root test. The structural break test will expose the year in which the structural break that leaves the economy with shock occurs.

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TABLE 1 Brief description of the variables

Variables	Brief form of variables	Measurement/calculation	Sources
Real gross domestic product	GDP (Y)	(Constant, 2010 US$) in logarithm form	World Bank Dev. Indicator, 2018
Squared real gross domestic product	GDP^2 (Y^2)	(Constant, 2010 US$) in logarithm form	World Bank Dev. Indicator, 2018
Foreign direct investment, net inflow	FDI	(%GDP)	World Bank Dev. Indicator, 2018
Energy use	EU	(kg of oil equivalent per capita) in logarithm form	World Bank Dev. Indicator, 2018
Carbon dioxide	CO_2 emissions	(CO2 emissions measured in metric tons per capita) in logarithm form	World Bank Dev. Indicator, 2018
Total natural resource rent	TNR	(%GDP)	World Bank Dev. Indicator, 2018

Source: Authors compilation.

Optimal lag selection was applied and was estimated with the vector autoregressive (VAR) lag-order selection criterion. The Akaike information criterion (AIC) was considered best among other criteria. Ideally, the outcome of the stationarity test forms a basis regarding the right method for the test of cointegration to adopt, but with the framing of bound (ARDL) testing, the cointegration test could be done without paying attention to conditions necessary for certain methodologies. Conditions such as large sample and variables integrated at first difference order, for methods like the Johansen and Engel cointegration to be utilized in ascertaining the cointegration, are suspended with the advent of bound (ARDL) testing. Cointegration estimation is conducted with bound testing and Johansen cointegration. Johansen cointegration was adopted as a robust check to the outcome of bound testing. After this, we adopted linear investigation for the explanation of the interactions between the dependent and independent variables. We adopted dynamic ARDL for an insightful exposition of the relationship that existed among the variables. We equally applied the Granger causality estimate for forecasting and robust checking of the linear estimation of the model.

In model specification, we framed the specification according to ARDL bound testing by Pesaran, Shin, and Smith (2001). Also, we adopted a model with both GDP per capita and squared GDP per capita to drive home one of the intents of this study on economic growth and environmental performance, hence ascertaining if EKC exists for the case of Venezuela. First, we specify the equation form of the model as:

$$CO_2 = \left(Y, Y^2, FDI, EU, TNR\right), \tag{1}$$

where $CO_2, Y, Y^2, FDI, EU, TNR$ represent carbon emission, real GDP per capita, squared real GDP per capita, FDI, net inflow, energy use, and TNR rent, respectively. The above equation is further expressed in both econometric and empirical form for effective empirical estimation:

$$lnCO_2 = b_1 + b_2 lnY_{it} + b_3 lnY_{it}{}^2 + b_4 FDI_{it} + b_5 lnEU_{it} + b_6 TNR_{it} + \mu_{it} \tag{2}$$

$$lnCO_2 = b_1 + b_2 lnY_{it} + b_3 lnY_{it}{}^2 + b_4 FDI_{it} + b_5 lnEU_{it} + b_6 TNR_{it} + \mu_{it} \tag{3}$$

For cointegration test, specification for the error correction model (ECM) is based on the ARDL bound test of Pesaran, and Shin (1998) and Pesaran, Shin, and Smith (2001) and is specified as follows:

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$$lnCO_{2t} = \partial + b_1 lnCO_{2t-1} + b_2 lnY_{t-1} + b_3 lnY^2{}_{t-1} + b_4 FDI_{t-1} + b_5 lnEU_{t-1} + b_6 TNR_{t-1} + \sum_{i=0}^{\rho-1} c_1 \Delta lnCO_{2t-i} + \sum_{i=0}^{q-1} c_2 \Delta lnY_{t-i} + \sum_{i=0}^{q-1} c_3 \Delta lnY^2{}_{t-i} + \sum_{i=0}^{q-1} c_4 \Delta FDI_{t-i} + \sum_{i=0}^{q-1} c_5 \Delta lnEU_{t-i} + \sum_{i=0}^{q-1} c_6 \Delta TNR_{t-i} + ECM_{t-i} + \mu_t. \quad (4)$$

From Equations 2–4, b_i and c_i denote long-run and short-run coefficients of the explanatory variables. The functional form between the dependent and independent variables will be based on elastic explanations (i.e., in percentage) because of the logarithmic expression of the variables. The relationship between the dependent and independent variables will be based on the sign of each coefficient. We expect b_2 and b_3 to bear positive and negative signs, respectively, in accordance with the EKC theory; hence, economic growth will amount to a negative impact on the environment at the initial stage of growth, but this is expected to revert to a positive impact on the environment at a certain point. The coefficient of FDI (b_4) is expected to bear either a positive or negative sign, which depicts a negative (pollution haven hypothesis) or positive (pollution halo hypothesis) impact on Venezuela's environment. The coefficients of energy use (b_5) and TNR rent (b_6) are expected to bear positive signs depicting an unfavourable impact on Venezuela environment. Also, from Equation 4, $\Delta ECM_{t-i}, \mu_t$ denote first difference, error correction, and residual term. Cointegration testing with bound is done by hypothesizing that there is no cointegration (null hypothesis). If after the estimation we find no cointegrating relationship among the selected variables, we fail to reject the null hypothesis, but if there is evidence of a cointegrating relationship among the variables, we reject the null hypothesis and accept the alternative hypothesis. Both the null and alternative hypothesis are expressed with long-run coefficients as follows:

$$\text{Null}\,(H_0) = b_1 = b_2 = b_3 = b_4 = b_5 = b_6 = 0;$$

$$\text{Alternative}\,(H_1) = b_1 = b_2 = b_3 = b_4 = b_5 = b_6 \neq 0.$$

To ascertain the presence of cointegration, we compare the F-stats and critical values of bounds (upper [I(1)] and lower [I(0)]) from the output of the bound cointegration test. If the F-stats is greater than the critical values of both bound tests at 1%, 5%, or 10% significance level, we conclude that cointegration exists, thereby rejecting the null hypothesis. If F-stats is less than the critical values of both bound tests, it means there is no cointegration, and thereby we fail to reject the null hypothesis. However, if the F-stats falls in between the two bounds, it means inconclusive. In addition, the Johansen (1988) cointegration test is adopted as a robust check to the bound test. It can predict additional cointegration which points to a long-run relationship between the variables. The Johansen cointegration test is done with the calculation of trace and max-eigenvalues, and the outcome is compared with their critical values.

5 | EMPIRICAL RESULTS AND DISCUSSION

5.1 | Summary of statistics

Statistical analysis was performed with the output displayed in Table 2. On the variability of the series, real per capita GDP and energy use appeared to be more variable among all other series. The normal distribution of the data was checked with the outcomes of the Jarque–Bera test. From the estimate

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TABLE 2 Summary of statistics

	CO_2	GDP	T_N_RESO	FDI	EU
Mean	6.208697	12831.85	18.35391	1.478201	2194.829
Median	6.083692	12709.50	17.56266	1.275494	2172.283
Maximum	7.701744	14920.45	34.89744	7.225257	2545.027
Minimum	5.154892	9830.737	8.519115	−1.338530	1965.165
Std. dev.	0.580161	1162.857	6.143653	1.718662	133.5872
Skewness	0.928611	−0.141551	0.547302	1.418339	0.560967
Kurtosis	3.505941	2.928381	3.198248	5.457657	3.176448
Jarque–Bera	5.249108	0.120808	1.753067	19.95634	1.827313
Probability	0.072472	0.941384	0.416223	0.000046	0.401055
Sum	211.0957	436283.0	624.0329	50.25884	74624.18
Sum sq. dev.	11.10737	44623771	1245.567	97.47532	588902.9
Observations	34	34	34	34	34

Source: Authors computation.

we observed that apart from FDI, all other variables were insignificant showing that the data were normally distributed.

5.2 | Stationarity test

Stationarity was performed with different methodologies, both conventional (Dickey–Fuller, 1979 and Philip–Perron, 1990) unit root test methods and the Zivot–Andrews structural break test. Findings from the traditional unit root test confirmed the stationarity of the variables in different orders, both at level and at first difference. This confirmed that the variables integrated in different or mixed order; hence, I(0) and I(1) order of integration existed among the selected variables. Having noted that the traditional methods of the unit root test are weak and confusing with regard to the existence of a structural break, we employed the Zivot–Andrews structural break test as robust check to the already estimated unit root. The output of the structural break test showed that structural breaks capable of leaving a permanent shock to the economy occurred in different periods. According to the finding, the breaks took place in the following years: 1998 and 2004 for the carbon emission variable, 1996 and 1999 for the FDI variable, 2003 and 1990 for the energy use variable, 2002 and 2004 for the real GDP per capita variable, and 2003 and 2006 for the TNR rent variable. Having a close look at the periods of the structural breaks, we noticed the break cycle within the period of our analysis is between 1990 and 2006. In the history of the oil-rich nation, Venezuela, the identified periods were turbulent times in the economic performance of the country. The petroleum sector of the country massively enhanced the economic performance with the policy of sowing the oil, but this positive performance was short lived because of the fluctuations in international petroleum prices and global economic recessions that took place within the identified break periods. Also, domestic economic problems such as inflation, corruption, inefficient management, and lack of skilled personnel considerably slowed the positive economic performance. The pressure on Venezuela's economy was also visible from the huge foreign debt, increased unemployment, and massive population with the event of illegal immigration. Considering the shocks that Venezuela's economy experienced, there are possibilities for the selected

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TABLE 3 Unit root test

Variables	@ LEVEL		First diff		Decision
	With intercept	Intercept and trend	With intercept	Intercept and trend	
			PP		
LCO_2	−3.2777**	−3.6466**	−13.7898***	−13.7709***	MIXED
LGDP	−1.8973	−2.4356	−4.2297***	−4.3529***	I(1)
LEU	−3.5318**	−4.3540***	−13.3168**	−15.8970**	MIXED
FDI	−2.6717*	−2.5376	−8.5303***	−9.5951***	MIXED
LTNR	−4.3610***	−4.2611***	−7.5221***	−7.2759***	MIXED
			ADF		
LCO_2	−3.2507**	−3.5914**	−6.7291***	−5.2123***	MIXED
LGDP	−2.4781	−2.8907	−4.4381***	−4.4417***	I(1)
LEU	−0.9174	−3.0858	−4.1596***	−3.3659*	I(1)
FDI	−2.7562*	−2.6356	−7.5684***	−7.5502***	MIXED
LTNR	−4.3610***	−4.2611***	−3.5945**	−3.5010*	MIXED

*Significant at 10%; **significant at 5%; ***significant at 1%. *p*-value according to Maclean et al. (1996) one-sided *p*-values.
Source: Author's computation.

TABLE 4 Zivot–Andrews structural break

Variables	ZA	*p*-value	Lag	Break years	CV (1%)	CV (5%)
LCO_2	−5.915	0.0008***	4	1998	−5.57	−5.08
LGDP	−4.4614	0.0663*	4	2002	−5.57	−5.08
FDI	−5.2485	0.0013***	4	1996	−5.57	−5.08
LEU	−3.938	0.0183**	4	2003	−5.57	−5.08
TNR	−5.1009	0.03395**	4	2003	−5.57	−5.08
			First diff			
ΔLCO_2	−6.664	0.0057***	4	2004	−5.34	−4.93
ΔLGDP	−5.2158	0.00125***	4	2004	−5.34	−4.93
ΔFDI	−8.635	0.0245**	4	1999	−5.34	−4.93
ΔLEU	−14.3086	0.0423**	4	1990	−5.34	−4.93
ΔTNR	−6.5963	0.11314	4	2006	−5.34	−4.93

Abbreviations: CV, coefficient of variation; ZA, Zivot–Andrews.
***, **, and * represent significance at 1%, 5%, and 10%, respectively.
Source: Authors computation.

variables in this study not to be stationary. The outputs of both the traditional and structural break tests are displayed in Tables 3 and 4.

5.3 | Long-run and short-run estimates, cointegration tests, and diagnostic tests

Outputs of the long- and short-run estimates, cointegration tests, and diagnostic tests are all presented in Table 5. Optimal lag was selected with AIC at 3. Result is available on request. Cointegration test was performed with bound test, and the findings confirmed the rejection of the null hypothesis at even

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TABLE 5 Autoregressive distributed lag (ARDL) dynamics (long run and short run) and cointegration test of the CO_2 model

Variables	Coefficients	SE	T-stats	Prob
		Short path		
D(LGDP)	−0.005577	0.000970	−5.750652	0.0000***
D(LGDP^2)	2.18E-07	4.05E-08	5.386960	0.0001***
D(FDI)	−0.100452	0.034472	−2.913993	0.0107**
D(LEU)	0.001281	0.000715	1.792394	0.0933*
D(TNR)	−0.036186	0.009325	−3.880323	0.0015***
Coint Eq(-1)	−0.834539	0.112848	−7.395241	0.0000***
		Long path		
LGDP	−0.005577	0.001271	−4.387508	0.0005***
LGDP^2	2.18E-07	5.22E-08	4.183347	0.0008***
FDI	−0.100452	0.046807	−2.146084	0.0486**
LEU	0.001281	0.000715	1.792394	0.0933
LTNR	−0.036186	0.014763	−2.451187	0.0270
Constant	24.79468	17.42179	1.423200	0.1751
R^2	0.868885			
Adj. R^2	0.737771			
D. Watson	2.255398			
Bound test (long path)				
F-stats	6.8***	K = 5,@ 1%	I(0)bound = 4.3	I(1)bound = 6.04
Wald test (short path)				
F-stats	13.43			
p-value	0.000001			
Serial correlation test				
F-statistics	0.257030 Prob. = 0.77			
Chi-square	1.179205 Prob. = 0.55			
Heteroscedasticity test				
F-statistics	0.754407 Prob. = 0.7040			
Chi-square	13.33021 Prob. = 0.577			

*, **, and *** denote significance at 1%, 5%, and 10%, respectively.
Source: Authors computation.

1% significance level with 6.8 and −7 as F&T-stats against the critical values of lower and upper bounds (4.3-6.04 and −3.4 and −4.79). Also, for a robust check on the outcome of the bound test, Johansen cointegration test was adopted, and cointegration was confirmed at two cointegration equations at 5% level. The result of the Johansen cointegration test is displayed in the table in Appendix 1. The model fit is expressed with $R^2 = 0.8688$ and adjusted $R^2 = 0.737$; this shows that about 90% (approximately) of the dependent variable (CO_2) is explained by the explanatory variables (*GDP per capita, FDI, natural resource rent, energy use*) and the remaining 10% is explained by the error term. Serial correlation problem is absent from our estimation. This is revealed with the outputs of both the Durbin–Watson (2.3) and Lagrange multiplier (LM) tests (prob. chi square = 0.55 and prob. F-stats = 0.77). Error term was shown to have been normally distributed in the model, thereby confirming the homoscedasticity of the model and affirming the absence of heteroscedasticity in the model.

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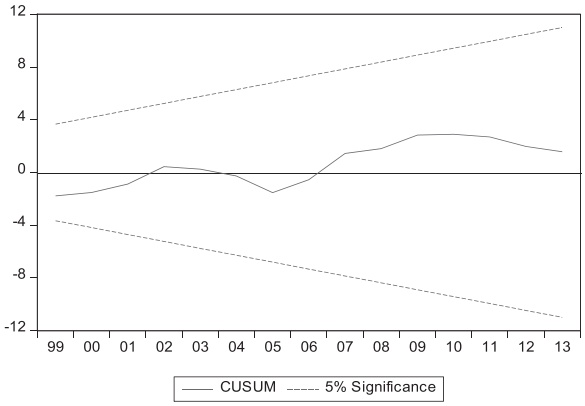

FIGURE 1 Plot of cumulative sum of recursive residuals. The blue line is the solid line, while the red lines that bounded the blue line are the critical bounds at 0.5 [Colour figure can be viewed at wileyonlinelibrary.com]

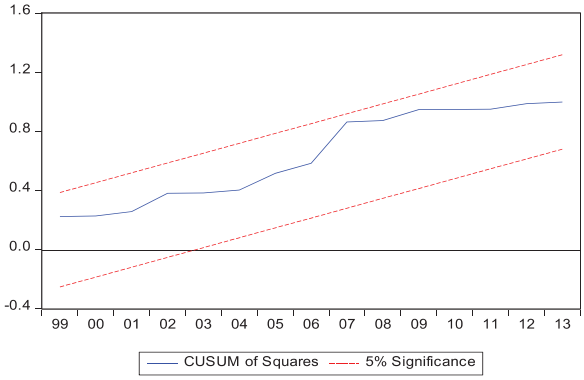

FIGURE 2 Plot of cumulative sum square of recursive residuals. The blue line is the solid line, while the red lines that bounded the blue line are the critical bounds at 0.5 [Colour figure can be viewed at wileyonlinelibrary.com]

This was confirmed with Breusch–Pagan–Godfrey heteroskedasticity test, which showed insignificant outcomes of prob. chi square and prob. F-stats (0.5). Cumulative sum and cumulative sum square tests (CUSUM and CUSUM^2) were applied to ascertain the stability of the model, and the outcome with blue line well bounded with two red lines confirmed the stability of the model. The results of CUSUM and CUSUM^2 are presented in Figures 1 and 2 right immediately after the table of the ARDL dynamics (long run and short run) and cointegration tests of the CO2 model. The speed of adjustment of the equilibrium in the long run was shown with the negative and significant value (−0.835) of the ECM. This shows that the disequilibrium that happened in the short run can be corrected in the long run at 83% speed of adjustment at 1% significance level. The empirical investigation of the short-run and long-run relationship between the drivers (*GDP*, *FDI, TNR, energy use*) of the environment and the environment (proxy with CO_2) is presented as follows: A significantly negative relationship is confirmed between environment quality (CO_2) and economic growth (real GDP per capita), while a significantly positive relationship is confirmed between squared GDP and environment quality. This dynamics of relationship that existed between economic growth (GDP per capita) and environment (CO_2) reflates in both the short-run and long-run systems for Venezuela. The finding exposes a positive pattern of development in the history of Venezuela's sustainability at the initial stage of development, but it was short lived. This trend distorts the anticipated U-shaped EKC for Venezuela and establishes an N-shaped EKC. This is not a surprise considering the development pattern in the history of Venezuela. The period from 1960 to the early 1970′s was a positive era in the development history of Venezuela. It was the era of *"sembrando el petroleo"* (meaning sowing the oil). Good management and policies such as import substitution and expansion of export-oriented enterprises were all in full force that led to diversification of Venezuela's economy. This brought about development of other rich deposits such as iron ore, nickel, coal, bauxite, and also hydroelectric power, which impacted positively on

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the both economic growth and environment. Quantitatively, a percent change/increase in economic growth (GDP per capita) will lead to 0.04 (−0.005577) significant (at 1%) decrease of CO_2 emissions (i.e., increase in good quality and performance of the environment) in both short-run and long-run periods. For the case of squared GDP per capita, a percent change/increase in economic growth (GDP per capita) will lead to 0.000000218 significant (at 1%) increase in CO_2 emissions (i.e., decrease in quality of the environment) in both short- and long-run periods. This finding supports the findings of Robalino-López et al. (2015) for Venezuela, and Ahmed and Long (2013) for Pakistan. Negative relationships are found for the cases of TNR rent and CO2 emissions and between FDI and CO_2 emissions in both the short run and long run, respectively. This supposes that a percent change/increase in natural resource rent and FDI will lead to 0.04 (−0.036186) and 0.10 (−0.100452) significant (at 5% each) decrease in CO_2 emissions (i.e., increase in good quality and performance of the environment). The key determinants and drivers of the economy are responding positively in sustenance of Venezuela's environment. This is a success story for Venezuela's environmental performance and a pointer that natural resources and FDI could amount to positive impacts to both the economic growth and environment. This might not be separated from the conservative policy of Venezuela such as banning all commercial mining activities in the Venezuelan Amazon and maintaining protection and a population density as low as 0.6 inhabitants/km^2 in more than 50% of the entire state (Huber, 2001). This finding supports the findings of Udemba et al. (2019) for the case of Indonesian FDI and environment and Şahinöz and Fotourehchi (2014) for the case of Turkey. However, energy use has proved a negative influence on Venezuela's environment. A positive relationship is established between energy use and CO_2 emissions (i.e., increase in degraded quality and performance of the environment) in both short- and long-run periods. This is not a surprise considering the energy mix being mainly fossil fuel applied in this study. This is a pointer that fossil fuel as a source of energy has a high level of carbon emission. A percent change/increase in the use of fossil fuel energy source will increase CO_2 emissions (i.e., decrease in good quality and performance of the environment) by 0.001281% in both short-run and long-run periods. This is in consonance with the findings of Al-mulali and Sab (2018), Basarir and Arman (2014), and Sbia et al. (2017).

5.4 | Granger causality estimates and analysis (VECM)

We applied causality estimation as a robust check to the ARDL dynamics of short-run and long-run estimates and as a forecasting insight into the dynamics and interactions among the selected variables. Ordinarily, empirical estimate on the basis of ARDL dynamics establishes the signs that point to the endogeneity relationship that exists between the explained and explanatory variables without necessarily exposing the forecasting power among the variables and where the force of interaction is coming from. Granger causality exposes the direction of the relationship among the variables: one-way (i.e., unidirectional causal relationship) and two-way (bidirectional causal relationship) transmissions. Following the mixed order of integration from the stationarity test, we utilized the vector error correction model (VECM) Granger causality method for causality analysis in this study. A nexus is established among economic growth, environment, and FDI from the findings of the Granger causality, which exposes the importance of FDI in the sustainable development of Venezuela. Hence, a unidirectional (*FDI is transmitting to environment*) causal relationship is established between environment (CO_2) and FDI. Bidirectional causal relationship is established between the GDP per capita and environment (CO_2). The output of the Granger causality is presented in Table 6.

6 | CONCLUSION AND POLICY SUGGESTION

Venezuela is a country so dependent on natural resource endowment with high natural resource exports and varying FDI inflows, which over the years have shaped the economic performance of the country.

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TABLE 6 Vector error correction model (VECM) Granger causality analysis/block exogeneity Wald tests

Variables	ΔLCO_2	ΔLGDP	ΔFDI	ΔLEU	ΔLTNR
ΔLCO_2	√√ √√	**2.837 [0.09]**	**6.807 [0.01]**	0.117 [0.72]	0.288 [0.59]
ΔLGDP	**2.836 [0.09]**	√√ √√	1.281 [0.25]	1.546 [0.21]	0.022 [0.88]
ΔFDI	2.315 [0.12]	0.493 [0.48]	√√ √√	0.154 [0.69]	2.399 [0.12]
ΔLEU	0.067 [0.74]	0.168 [0.68]	0.224 [0.64]	√√ √√	0.319 [0.57]
ΔLTNR	0.245 [0.62]	**3.351 [0.07]**	0.765 [0.38]	0.458 [0.50]	√√ √√

Note: Bold figures in brackets are the prob. that represent 10%, 5%, and 1% significance, respectively, while the figures before the brackets are the chi-squares (χ^2) = Chi-squares (χ^2) [*p*-values].

There is always a perception that countries endowed with high natural resources are susceptible to poor environmental performance because of high emission from oil exploration and gas flaring. This suggested our undertaking of the task of an empirical analysis of the effects of the endowment on economic growth and environmental conditions. Examining both the EKC and PHH in the country is expected to help explain similar possible implications for other economies that are also dependent on natural resources. We utilized different scientific approaches such as structural break, dynamic ARDL analysis of short and long run, and Granger causality test to uncover both the environmental and economic implications of natural resources in Venezuela's sustainable development. Our discussions are based on the findings from both ARDL and Granger causality analyses. From the ARDL estimations, we found an N-shaped Kuznets curve, which means that the classical U-shaped Kuznets is suspended for the case of Venezuela. We also found both natural resources and FDI to impact positively on the environment, and this confirmed the pollution halo hypothesis for Venezuela. Fossil fuel energy source is found to negatively impact Venezuela's environment with a positive relationship between energy use and CO_2. From the Granger causality finding, a unidirectional Granger causality is found to transmit from FDI to environment, while bidirectional Granger causality is found to transmit between economic growth and environment. With the findings from both analyses, especially from VECM Granger causality, a nexus is established among economic growth, environment, and FDI. The findings from Granger causality support the findings of the pollution halo hypothesis from the ARDL approach. This is a pointer to the importance of FDI in sustaining the environmental performance in Venezuela.

With the findings so far, we can say Venezuela's sustainable development can be achieved if certain policies can be implemented. Among the policies that needed to be framed and implemented are FDI-attracting policies that will encourage foreign investors to invest and maintain a healthy environment. This is based on the impact of FDI as discovered from our findings. As noted earlier, Venezuela's authorities should maintain their conservative policy such as banning all illegal commercial mining activities in the Venezuelan Amazon and maintaining protection and a population density as low as 0.6 inhabitants/km^2 in more than 50% of the entire state. This will help to reduce the pressure on the environment. A long-term goal to achieve green energy by adopting renewable energy sources is needed among the policies to foster sustainable development in Venezuela.

However, there is still room for more research on the sustainable development of Venezuela. Subsequent research is encouraged with extended data beyond the scope of the data adopted in this study. Other variables such as trade openness and ecological footprint should be considered in any similar research. Conclusively, examining the PHH and EKC hypothesis in the case of Venezuela is expected to help explain similar possible implications for other economies that are also dependent on natural resource revenues. This study also has an implication to the neighbouring Caribbean countries such as Panama, Colombia, Ecuador, and Brazil in proffering sustainability solutions by adopting the policies highlighted in this study. FDI is considered among the factors impacting positively on the countrie's environment; hence, a policy attracting FDI and monitoring investors to ensure clean

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economic activities is of great importance to Venezuela's neighbouring countries as well. So, this study will serve as a reference for policy framing for other similar economies and neighbouring countries.

CONFLICTS OF INTEREST

There are no conflicts of interest at any level of this study.

DATA AVAILABILITY STATEMENT

Data are available from the authors on request.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/issj.12378

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APPENDIX 1

Johansen cointegration test

Hypothesis No of CE(S)	Eigenvalue	Trace stats	Critical value @ 5%	Prob.**
r≤0	0.664331	89.22560	69.81889	0.0007
r≤1	0.570653	55.38506	47.85613	0.0084
r≤2	0.349166	29.17489	29.79707	0.0589
r≤3	0.271589	15.86039	15.49471	0.0440
r≤4	0.176948	6.036796	3.841466	0.0140
		Maximum eigenvalue		
Hypothesis No of CE(S)	**Eigenvalue**	**Max-eigen stats**	**Critical value @ 5%**	**Prob.****
r≤0	0.664331	33.84055	33.87687	0.0505
r≤1	0.570653	26.21017	27.58434	0.0741
r≤2	0.349166	13.31450	21.13162	0.4237
r≤3	0.271589	9.823598	14.26460	0.2238
r≤4	0.176948	6.036796	3.841466	0.0140

***, **, and * represent significance at 1%, 5%, and 10%, respectively. Trace test indicates two cointegrating eqn(s) at the 0.05 level. Max-eigenvalue test indicates no cointegration at the 0.05 level.
Source: Authors computation.

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