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A Study of Environmental Degradation in Turkey and its Relationship to Oil Prices and Financial Strategies: Novel Findings in Context of Energy Transition

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The current empirical literature ignores the possible influence of oil prices on environmental degradation through fiscal policy instruments. Contributing to the literature, this study explores the influence of oil price on the environmental degradation in Turkey through fiscal policy instruments, using a novel methodology of the bootstrap ARDL approach. The FMOLS, CCR, DOLS, and ARDL models are used to examine the long-run linkage among the tested variables. The findings from estimating models demonstrated that government expenditures positively affected environmental degradation in Turkey. In contrast, the taxation revenues negatively affected the environmental degradation. Furthermore, the empirical outcomes affirm that oil prices have a powerful effect on the levels of Turkey's environmental pollution through taxation revenues, energy, and GDP factors. Therefore, the study suggests that the Turkish policymakers should design policies to avoid any undesirable impacts of the spillover effects of the oil price on the environment using fiscal policy channels. In this sense, the government in Turkey should design a framework that includes financial incentives such as low taxation rates on green energy investment. In addition, the policy markets in Turkey should start to use the carbon tax policy, which is one of the most efficient tools to reduce environmental pollution.

Keywords: Turkey, CO_2 emission, fiscal policy, bootstrap ARDL, energy

INTRODUCTION

In recent years, there have been a growing number of empirical studies on the environmental Kuznets curve hypothesis (EKC-H). According to the EKC-H, environmental quality deteriorates by increasing CO_2 emissions at the first stage of economic growth. But after a specific period, an increase in economic development would result in decreases in the level of CO_2 emissions. The logic of the EKC is based on the fact that environmental pollution increases rapidly during the first stage of the economic development process because a high emphasis is placed on the increasing material output, and the economy is more concerned with generating income than maintaining and reducing the environmental pollution. Since the pioneering work of Grossman Gene and Krueger (1993), numerous empirical studies have tested the validity of the EKC using a variety of environmental metrics. For instance, Qashou et al. (2022); Anwar et al., (2022); Ali et al., (2022); Minlah and Zhang, (2021); Altarhouni et al., (2021); Abumunshar et al., (2020); Leal and Marques, (2020); Shahbaz and Sinha, (2019); Nathaniel et al., (2019) tested the ECK in different selected countries. Using different methods, the findings confirmed that the ECK is accepted in the tested countries. In this context, the study aims to retest the ECK in Turkey using the bootstrap ARDL testing approach. The current research is different from the current empirical studies in two ways. First, several studies explore the impact of the oil price on environmental degradation (see, e.g., Mensah et al., 2019; Malik et al., 2020; Li et al., 2020; Suleiman et al., 2020; Ghazouani, 2021). In the existing empirical studies, the possible influence of the oil price on environmental degradation through fiscal policy channels has been ignored. Hence, the study aims to present a new perspective to the literature by exploring the effect of oil price on the level of carbon through the fiscal policy channel. Second, the current research uses a novel co-integration technique of ARDL, as presented by McNown et al. (2018), to examine the tested variables.

According to recent empirical studies, oil price volatility significantly impacts several economic factors (see, e.g., Mahmood and Murshed, 2021; Su et al., 2021; Xia et al., 2022). The significant impact of the oil price on economic factors can be explained by some factors such as petroleum-exporting economics vs. petroleum-importing economics. In petroleum-importing economics, an oil price negatively affects the real-actual income. In this context, if oil prices increase, inflation rates will increase, leading to an increase in the rate of interest and taxation rates. Hence, any increase in interest rates and tax rates will lead to an increase in the cost of finance sources. Subsequently, it will lead to a decline in the total of new investments and energy consumption levels. However, the main objective of this research is to test the influence of the oil price on the level of carbon emission through the fiscal policy channels.

The fiscal policy is one of the main significant instruments for any government to regulate and improve the economy. In this context, the government's expenditures on goods and services and tax revenues can be defined as the main significant fiscal policy instruments. However, fiscal instruments play a significant role in achieving main macroeconomic goals such as economic development, a stable external balance, and price stability (Katircioglou and Katircioglou 2018). There are two types of fiscal policies: the tight fiscal policy and expansionary fiscal policy. The tight fiscal policy can be used in economic prosperity times. For instance, during economic prosperity, the inflation rates can often jump to high rates. To reduce the inflation rates, the government's policymakers may use the tight fiscal policy to reduce the money supply and aggregate demand, which in turn leads to a decline in the output and price levels (Rafique et al., 2021). However, the tight fiscal policy works by increasing the tax rates and/or decreasing government expenditures, while the expansionary fiscal policy involves tax rate cuts and increases government expenditures on projects,

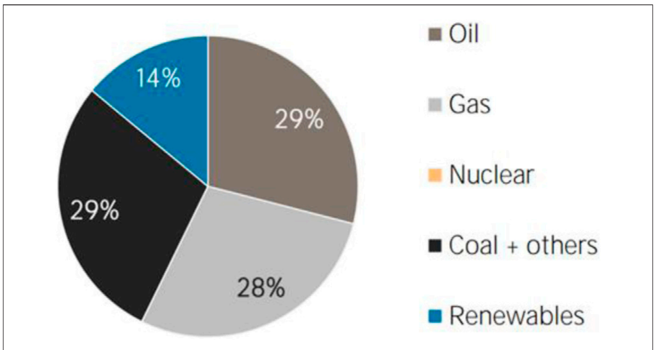

FIGURE 1 | Share of renewable energy supply from the total energy consumption in Turkey in 2014: Source: International renewable energy agency

which leads to an increase in the money supply to the markets. Hence, any change in the fiscal policy has a powerful influence on the economic performance. Subsequently, it will affect energy consumption, which in turn may affect environmental degradation.

In the current literature, limited studies tested the impact of the fiscal policy on the level of carbon emissions. (See. Frederik and Lundström, 2001; He et al., 2019; Katircioglou and Katircioglou 2018; Shahzad et al., 2022). However, the study suggests that fiscal policies may affect the level of environmental degradation from two angles. First, the policymakers can use fiscal policy instruments to mitigate carbon emissions by using carbon taxes. However, the carbon tax is one of the sufficient instruments to reduce carbon emissions, which provides an incentive tool for markets to use more environmental friendly production processes. Subsequently, this process will lead to reducing the carbon emission levels. Second, the policymakers can use fiscal policy instruments to mitigate carbon emissions by supporting green energy projects. For instance, reducing the tax rates on green energy investment, which in turn leads to a decrease in the CO_2 emissions.

Turkey is a developing economy; it represents an important investigation topic for exploring the interaction among the prices of oil, consumption of energy, GDP, fiscal policy, and CO_2 emissions, which targets to be among the top-10 economies globally in terms of economic growth rates. Turkey made efforts to boost its economic growth, FDI, and trade. In this line, GDP/per-capita increased from 4,980 USD in 1980 to 13,300 USD in 2014. Total exports rose from 5 billion United States dollars (USD) in 1980 to 256 billion USD in 2014. The total foreign investment reached around 127 billion USD from 2002 to 2014.

Although Turkey has faced some crises, such as the 2001 crisis, the Turkish banking sector experienced a positive development from 2002 to 2015; for example, the credits provided by the banking sector to the private sector reached around 50% of GDP. On the other hand, Turkey, as an emerging economy, is still not a forerunner in international policies and makes efforts to tackle the challenges of climate change (Altarhouni et al., 2021). The changes in the amount of energy consumption followed an interesting path over the last few years in Turkey. **Figure 1** shows that Turkey's renewable energy consumption was 14% of the total energy consumption in 2014. In contrast, Turkey's nonrenewable energy consumption represented more than 86% of the total energy consumption in 2014. However, Turkey is an energy-importing country; more than 50% of the energy needed is imported from other countries. Turkey mainly imports oil from Russia, Iraq, Kazakhstan, and India. Hence, as a strong petroleum-importing economy, Turkey is directly affected by any significant change in oil prices. However, the prime objective of the present research study is to explore the influence of oil prices on the level of carbon emissions through fiscal policy, energy, and economic growth.

The research structure is organized as follows: the second section introduces the review of empirical literature; the third section introduces data, models, and methodology; the fourth and fifth sections show the empirical findings and the conclusion, respectively.

LITERATURE REVIEW

Economic Growth and Carbon Emissions

Numerous empirical studies have tested the validity of the EKC using a variety of environmental metrics. For instance, (Anwar et al., 2022; Ali et al., 2022; Minlah and Zhang,2021; Altarhouni et al., 2021; Abumunshar et al., 2020; Leal and Marques, 2020; Shahbaz and Sinha, 2019; Nathaniel et al., 2019). Leal and Marques (2020) affirmed that the EKC is valid in 2020 OECD countries. Altıntaş and Kassouri (2020) tested the EKC in 14 European countries. The empirical outcomes affirmed that the EKC was accepted in 14 EU countries for the 1990–2014 period. Minlah and Zhang (2021) investigated the EKC in Ghana over the examined period from 1960 to 2014. The empirical outcomes revealed that the EKC is valid for the tested period. Similarly, Altarhouni et al. (2021) confirmed that the EKC was valid in Turkey from 1981 to 2016. However, these studies affirmed that an increase in economic growth levels would increase the level of CO_2 emissions. But after a specific period, an increase in the economic development would result in decreases in the level of CO_2 emissions. In contrast, Jobert and Karanfil (2007) used the Granger causality test, and Ocal and Aslan (2013) used the ARDL test. The authors found no association between GDP and levels of environmental pollution in Turkey for 1960–2003 and 1990–2010 periods, respectively.

Energy Consumption and Carbon Emissions

In the current empirical literature, various studies investigated the link between renewable energy and nonrenewable energy consumption and the level of CO_2 emissions. Dogan and Ozturk (2017) checked the link between energy consumption and the United States CO_2 emissions over the tested period from 1960 to 2010. Using the ARDL testing model, the findings confirmed that the use of nonrenewable energy consumption (NREC) has a positive impact on CO_2 emissions. Koengkan et al. (2020) tested the linkage among NREC and levels of CO_2 emissions in five selected countries over the examined period 1980–2014. By utilizing a panel VAR testing model, the outcomes showed that there is a positive linkage between NREC and CO_2 emissions. Pao et al. (2011) analyzed the causal connection between NREC and CO_2 emissions in Russia. The findings showed that there is a causal relationship between NREC and CO_2 emissions over the period from 1992 to 2007. In Turkey, Altarhouni et al. (2021) used the ARDL model and showed that NREC affected the level of carbon emissions over the period from 1980 to 2014. Alola and Donve, (2021) affirmed that NREC positively influenced carbon emission in Turkey over the period from 1965 to 2014.

On the other hand, several empirical studies tested the impact of REC on environmental pollution (Fatima et al., 2020; Wang et al., 2021; Paramati et al., 2022). In this sense, Shafiei and Salim (2014) tested the association between REC and environmental pollution in different selected OECD countries from 1980 to 2011. The findings found an inverse linkage between REC and environmental pollution using the AMG panel data testing model. Bilgili et al. (2016) analyzed the influence of REC on CO_2 emissions in 17 countries for the 1980–2011 period; the findings found the REC has an inverse impact on CO_2 emissions in 17 selected countries over the investigated period. Chen and Geng (2017) tested the influence of REC on carbon emissions for 30 OECD countries over the period from 1980 to 2011 (query). The outcomes showed a negative linkage between REC and carbon emissions. Namahoro et al. (2021) analyzed the impact of REC on CO_2 emissions in East African countries over the period from 1980 to 2016. The results revealed that REC negatively affects CO_2 emissions in East African countries. In Turkey, Magazzino (2016) tested the linkage among REC and CO_2 emissions over the tested period from 1992 to 2013. Using the panel VAR model, the outcomes affirmed that REC affects carbon emissions negatively. Abumunshar et al. (2019) employed the ARDL model over the tested period from 1980 to 2014 and suggested that REC has an inverse relation with carbon emissions.

Fiscal Policy and CO_2 Emissions

Enormous empirical studies have explored the interaction between macroeconomic variables and carbon emissions, whereas the studies that tested the impact of the fiscal policy on carbon emissions are limited. Frederik and Lundström (2001) used the fixed-effect testing model and tested the influence of the government size on CO_2 emissions in 77 selected countries. The findings showed that there is an inverse interaction amongst the government size on CO_2 emissions over the period 1977–1996. Bernauer and Koubi (2006) used the OLS testing model and tested the influence of the government size on CO_2 emissions in 42 selected countries over the period 1971–1996. The findings revealed that there is a positive interaction amongst the government size and CO_2 emissions over the period 1971–2001. Adewuyi (2016) used the GMM testing model and tested the influence of government expenditures on CO_2 emissions in different selected countries over the period 1990–2015. The findings revealed that there is a positive and significant interaction amongst government expenditures and

CO_2 emissions over the investigated period. Yuelan et al. (2019) utilized ARDL bound model and tested the influence of taxation revenues on CO_2 emissions in China, over the period 1980–2019. The findings revealed that there is a positive and significant interaction between taxation revenues, and emissions over the investigated period, whereas some studies demonstrated that there is no significant link between the government size, taxation revenues, and CO_2 emissions. For instance, Halkos and Paizanos (2013) used the fixed-effect testing model and tested the influence of government expenditures and taxation revenues on CO_2 emissions in 42 selected countries, over the period 1980–2000. The findings indicated that there is no significant interaction amongst the government size and CO_2 emissions. In Turkey, Katircioglou and Katircioglou (2018) used the ARDL-bound testing model and tested the influence of government expenditures and taxation revenues on CO_2 emissions in Turkey, over the period 1960–2013. The findings indicated that there is an inverse and significant interaction amongst taxation revenues and CO_2 emissions over the investigated period, while some empirical studies tested the impact of carbon taxation on the levels of environmental degradation: For instance, Ghazouani et al. (2020) explored the influence of the carbon tax on CO_2 emissions in eight selected countries. The findings showed a positive impact of the carbon tax on carbon emission deduction. Wolde-Rufael and Mulat-Weldemeskel (2021) tested the influence of the environmental tax on CO_2 emissions in seven emerging economies for the period 1994–2015. Using the augmented mean group (AMG), the findings indicated that the total environmental tax was negatively and significantly linked to CO_2 emissions.

Oil Price and CO_2 Emissions

The empirical studies that explored the impact of oil prices on environmental degradation levels are varied. In this context, Wong et al. (2013) tested the impact of oil prices on environmental degradation from 1980 to 2010. The outcomes showed that the oil price harms carbon emission levels for selective OECD economies. Mensah et al. (2019) used the panel ARDL method and indicated that the oil price harms environmental pollution levels. Malik et al. (2020) tested Pakistan's oil price and the environmental pollution link. Using the ARDL testing model, the outcomes indicated that the oil price negatively influences environmental degradation. Zhao et al. (2021) explores the impact of oil price fluctuations on the levels of environmental degradation. Applying the ARDL method, the outcomes illustrated that the oil price increases environmental pollution in Pakistan in the short run. At the same time, they were decreasing environmental pollution in the long run. Li et al. (2020) investigated the impact of energy prices on China's environmental degradation. Using the STIRPAT model, the outcomes illustrated that the oil price adversely influences China's environmental degradation. Haque (2020) tested crude oil on carbon dioxide emissions. The results indicated that the oil price negatively affected carbon emission in Gulf Cooperation Council countries over the 1985–2014 period. Abumunshar et al. (2020) approved that oil prices negatively affected the levels of carbon emissions. In the causal connection between oil price and CO_2 emissions, Li et al. (2019) and Suleiman et al. (2020) affirmed a causal association among the oil price, NREC, and emissions levels in China and Tunisia, respectively. On the other hand, some studies illustrated that there is a positive connection between oil price and CO_2 emissions. Apergis and Payne, (2015) affirmed a positive connection between the oil price and environmental degradation levels in 11 selected countries for the 1980–2010 period. Nwani (2017) affirmed that oil prices positively affected the levels of carbon emissions in Ecuador. Ghazouani (2021) affirmed a significant increase in the oil price positively affect the levels of CO_2 emissions in Tunisia.

DATA, MODEL, AND METHODOLOGY

Data and Model

The conventional EKC model is employed to examine the linkage between economic growth (GDP) and the level of CO_2 emissions. The linkage amongst GDP and the level of CO_2 emissions are presented as an inverted $U-$ shaped linkage (Ocal and Aslan 2013; Abumunshar et al., 2020; Altıntaş and Kassouri, 2020; Altarhouni et al., 2021; Minlah and Zhang, 2021). Hence, the factors of GDP and GDP quadratic are the prime determinants of CO_2 levels. Thus, the EKC model is formulated as follows:

$$CO_2 = f\left(GDP, GDP^2\right), \tag{1}$$

where CO_2 is the level of carbon emissions, GDP is the economic growth, and GDP^2 is the quadratic in Turkey. The present study is different from the previous studies by testing the impact of oil prices, taxation revenues, governmental expenditures, REC, and NREC on Turkey's levels of carbon emissions, using the newly developed ARDL model, as presented by McNown et al. (2018). Hence, the selected model of this research is presented as follows:

$$\begin{aligned} lnCO_{2\,t} = {} & \beta_0 + \beta_1 lnCO_{2t} + \beta_2 lnOP_t + \beta_3 lnGE_t + \beta_4 InT \\ & + \beta_5 lnGDP_t + \beta_6 InGDP_t^2 + \beta_7 lnREC_t + \beta_8 lnNREC_t \\ & + \varepsilon it, \end{aligned} \tag{2}$$

where In $\ln CO_2$ is the logarithm of the levels of carbon emissions in kilotons, $lnOP$ *is* brent crude oil prices (Abumunshar et al., 2020), $InGE_t$. is governmental expenditures as (% of GDP) (Katircioglu and Katircioglu, 2018), lnT *is* tax revenues (% of GDP), $lnREC$ is a percent of renewable energy in Turkey from the total energy consumption (Abumunshar et al., 2020), $lnNREC$ is the total nonrenewable energy consumption in Turkey (natural coal, oil, and gas), $lnGDP$ is the constant 2010 USD, and $lnGDP^2$ is the GDP-square (Katircioglu and Katircioglu, 2018). The data of this study are collected from the World Bank. The data retrieved are yearly data, and it covers the period 1981–2015. **Table 1** shows the specification and source of the variables of data. **Figure 2** shows the plot of the selected series of the current study at the natural logarithm. The tested time-series plot shows some economic fluctuations in Turkey over the tested period, such as the 2001 crisis and 2008 crisis.

TABLE 1 | Variable specification and source of the data.

Variables	Specification	Presentation
Carbon emissions	Carbon emissions in kilotons	CO_2
Oil prices	Brent crude oil prices	OP
Government expenditure	Government expenditure (% of GDP),	GE
Tax revenues	Tax revenues (% of GDP),	T
Renewable energy consumption	A share of total final energy consumption	REC
Non-renewable-energy consumption	Consumption of oil, coal, natural gas	NREC
Economic growth	GDP in constant 2010 USD	GDP
Economic growth square	GDP-square	GDP^2

The data collected from the World Bank

Methodology

The current study uses two unit-root tests with structural-break dates to explore the stationary level among the tested variables. The study uses the test by Zivot-Andrews, (2002) with one break date and the Perron and Vogelsang (1993) test with two break dates. To check the co-integration among the investigated variables, the study applies the B-ARDL testing technique. The new technique of the ARDL approach is preferred over other co-integration techniques due to its advantage in estimating while addressing the statistical issues of size weakness, which other co-integration tests failed to address. Moreover, the B-ARDL (McNown et al., 2018) technique is preferred over other co-integration tests due to the new approach, concerning the integration features of the tested order. Hence, the prime objective of this study is to present a new perspective by exploring the link among tested variables using the B-ARDL (McNown et al., 2018) technique. This test includes a *t-test* $t_{dependent}$ or *F-test* $F_{independent}$ on the estimated coefficients of the independent variables. The H_0 of the $t_{dependent}$ test is $\sigma 1 = 0$. The H_1 of the $t_{dependent}$ test is $\sigma_1 \neq 0$. On another hand, the H_0 of the $F_{independent}$ test is $\sigma_2 = \sigma_3 = \sigma_4 = \sigma_5 = \sigma_6 = \sigma_7 = \sigma_8 = 0$. The H_1 of the $F_{independent}$ test is $H_1: \sigma_2 \neq \sigma_3 \neq \sigma_3 \neq \sigma_4 \neq \sigma_5 \neq \sigma_6 \neq \sigma_7 \neq \sigma_8 \neq 0$.

The critical values of the new technique of the ARDL test are generated on the specific features of integration for each studied series. Subsequently, this procedure will eliminate unstable outcomes of the ARDL-bound testing model. The CV generation in the novel method of B-ARDL is based on bootstrap simulation; however, the updated method of ARDL aims to present better outcomes than other co-integrations techniques. For instance, the CV in the traditional ARDL test allows for (1) investigated variables to be endogenous (Samour et al., 2022), whereas the CV in the B-ARDL test allows for the endogeneity of all tested explanatory variables. Furthermore, the B-ARDL testing technique is more recommended for time-series models that include more than one explanatory tested variable (McNown et al., 2018).

The examined ARDL model ($lnCO_2$, $lnOP$, $lnGE, lnT, lnGDP$, $lnGDP^2\, lnREC$, and $lnNREC$) is formulated in the following equation:

$$\begin{aligned}\Delta lnCO_{2t} = {} & \beta_0 + \sum_{i=1}^{k} y_1 \Delta lnCO_{2t-i} + \sum_{i=1}^{k} y_2 \Delta lnOP_{t-i} \\ & + \sum_{i=1}^{k} y_3 \Delta lnGE_{t-i} + \sum_{i=1}^{k} y_4 \Delta lnT_{t-i} \\ & + \sum_{i=1}^{k} y_5 \Delta lnGDP_{t-i} + \sum_{i=1}^{k} y_6 \Delta lnGDP^2_{t-i} \\ & + \sum_{i=1}^{k} y_7 \Delta lnREC_{t-i} + \sum_{i=1}^{k} y_8 \Delta lnNREC_{t-i} \\ & + \sigma_1 lnCO_{2\,t-1} + \sigma_2 lnOP_{t-1} + \sigma_3 lnGE_{t-1} + \sigma_4 lnT_{t-1} \\ & + \sigma_5 lnGDP_{t-1} + \sigma_6 lnGDP^2_{t-1} + \sigma_7 lnREC_{t-1} \\ & + \sigma_8 lnNREC_{t-1} + \varepsilon_{1t},\end{aligned} \tag{3}$$

where Δ is the first difference operator, and $lnCO_2$, $lnOP, lnGE, lnT, lnGDP$, $lnGDP^2$, $lnREC$, and $lnNREC$ are the tested variables; K means the lag optimal, and ε_{1t} is the error term of the investigated model. The error correction term (ECT) is formulated in **Eq. 4**:

$$\begin{aligned}\Delta lnCO_{2t} = {} & \beta_0 + \sum_{i=1}^{k} \beta_1 \Delta lnCO_{2t-i} + \sum_{i=1}^{k} \beta_2 \Delta lnOP_{t-i} \\ & + \sum_{i=1}^{k} \beta_3 \Delta lnGE_{t-i} + \sum_{i=1}^{k} \beta_4 \Delta lnT_{t-i} \\ & + \sum_{i=1}^{k} \beta_5 \Delta lnGDP_{t-i} + \sum_{i=1}^{k} \beta_6 \Delta lnGDP^2_{t-i} \\ & + \sum_{i=1}^{k} \beta_7 \Delta lnREC_{t-i} + \sum_{i=1}^{k} \beta_8 \Delta lnNREC_{t-i} \\ & + ECT_{t-1} + u_t,\end{aligned} \tag{4}$$

where represents a change in $lnCO_2$, $\beta_1 lnOP_t, lnGE, lnT, lnGDP$, $lnGDP^2 lnREC$, and $lnNREC$. The statistical significance of ECT_{t-1} with a negative $e_{(-)}$ sign approves the adjustment velocity in the short and long levels.

To affirm the reliability of ARDL results and avoid functional form misspecification caused by the volatility of the series, diagnostic tests for the parameters are required. The study uses some diagnostic tests to check the stability of the models. In this regard, the study employed the normality test (Normality–^{test}), the Breush-Pagan Godfrey test for heteroscedasticity (Heteroscedasticity^{t2}), the ARCH test (ARCH^{test}), LM (LM^{test}), and Ramsey RESET test (Ramsey^{test}). The normality test is utilized to affirm that the tested model is usually disrupted. Next, the heteroscedasticity test is utilised to affirm that there is no heteroscedasticity and to affirm the absence of autocorrelation in the tested model. Finally, the Ramsey test is utilized to affirm that the tested model is correct and stable.

Furthermore, the stability of the ARDL testing model can be checked by using the (CUSUM and CUSUM square) tests. To affirm the ARDL findings in the long run, the study uses the following estimating tests: the fully modified least squares (FM-OLS) regression, as introduced by Phillips and Hansen, (1990), canonical co-integrating regression (CCR.) as developed by Park (1992), co-integrating regression, and dynamic-OLS (DOLS), as developed by Stock and Watson (1993). These estimating tests use different corrective techniques except for the bias and non-centrality of the second-order. It is, therefore, imperative to apply these tests to affirm the long-run linkage among OP, GE, T, GDP, GD P^2, NREC, REC, and CO_2 variables. All genetic projections will be corrected in the FM-OLS test, whereas the CCR testing model only corrects data and selects connections that represent

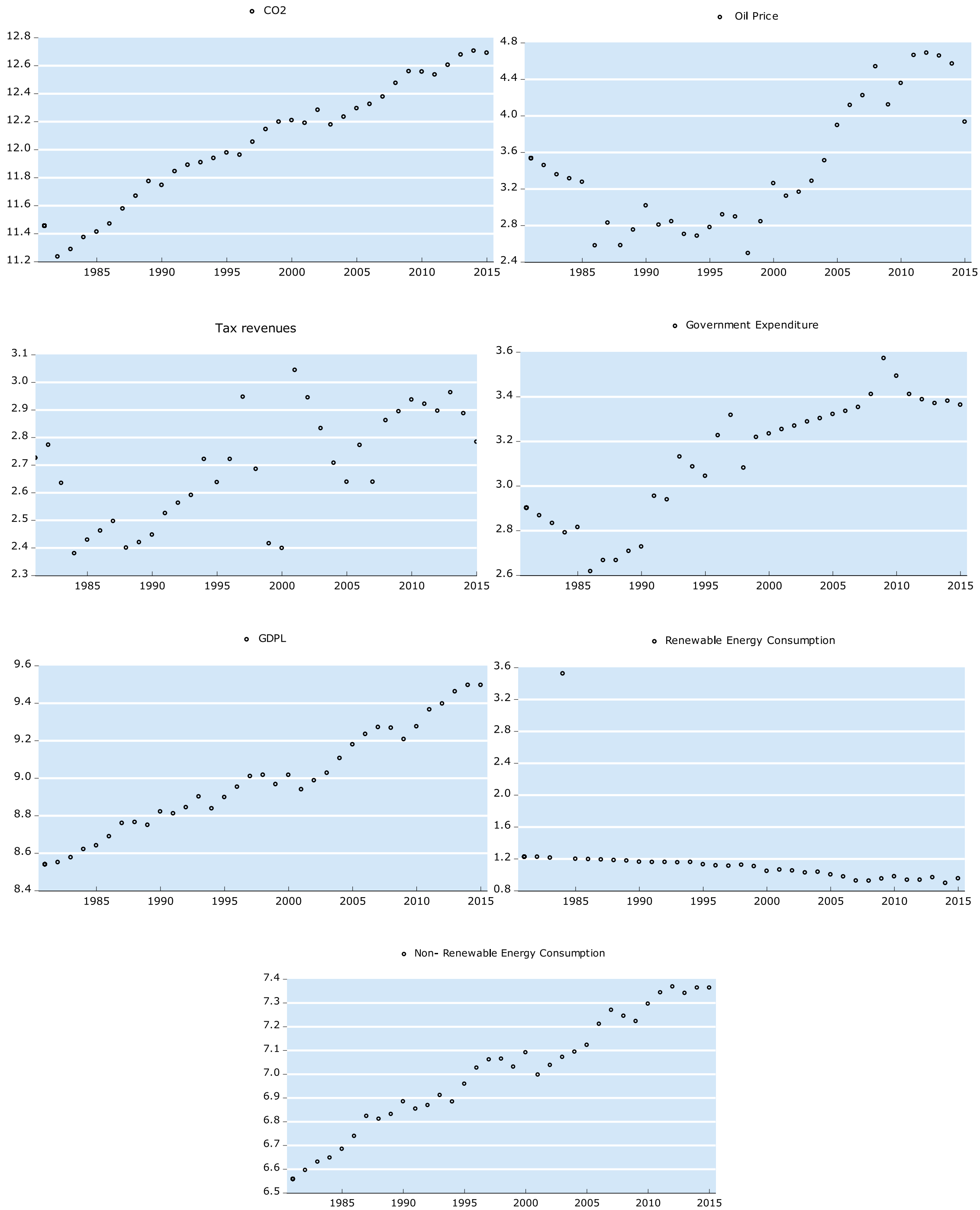

FIGURE 2 | Tested time series at the natural logarithm over the period from 1981 to 2015.

the correct canonical class interaction. In contrast, D-OLS includes abbreviation parameters that correct non-systemic bias.

The causal linkage among $lnOP, lnGE, lnT, lnGDP, lnGDP$, $lnGDP^2$, $\ln REC, and \ln NREC$ is explored by applying the Granger causality testing approach within V-ECM. This testing model examines if there is co-integration amongst the selected variables. The main advantage of V-ECM lies in its strength in capturing both the short- and long-term equilibrium linkage amongst the tested variables. However, the Wald test is utilized to measure the causal link in the short run, whereas to examine the causal linkage among the tested variable of the current study, in the long run, the t_{test} of the lagged – ECT is utilized. The Granger causality technique approach includes (ECT) to determine and measure the deviations of the examined variables from the short-run to long-run equilibrium level; the error correction model is examined in **Eqs 5–12**:

$$\begin{aligned}\Delta lnCO_{2t} = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnCO_{2t-i} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnOP_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnGE_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnT_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnGDP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP^2_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta lnOP_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnGE_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnT_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnGDP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP^2_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{6}$$

$$\begin{aligned}\Delta lnGE_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnGE_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnT_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnGDP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP^2_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta lnT_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnT_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnGE_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnGDP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP^2_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{8}$$

$$\begin{aligned}\Delta lnGDP_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnGDP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnGE_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnT_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP^2_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta lnGDP^2_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnGDP^2_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnGE_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnT_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP_{t-1-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{10}$$

$$\begin{aligned}\Delta lnREC_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnGE_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnT_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnGDP^2_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnNREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{11}$$

$$\begin{aligned}\Delta lnNREC_t = \beta_0 &+ \sum\nolimits_{i.=1}^{p}\beta_1\Delta lnNREC_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_2\Delta lnCO_{2t-i}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_3\Delta lnOP_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_4\Delta lnGE_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_5\Delta lnT_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_6\Delta lnGDP_{t-1}\\ &+ \sum\nolimits_{i.=1}^{q}\beta_7\Delta lnGDP^2_{t-1} + \sum\nolimits_{i.=1}^{q}\beta_8\Delta lnREC_{t-1}\\ &+ \partial_1\ ECT_{t-1} + e_t,\end{aligned} \tag{12}$$

EMPIRICAL FINDINGS AND DISCUSSIONS

The outcomes of Perron–Vogelsang and Zivot–Andrews unit root tests are displayed in **Table 2**. The outcomes are revealed that all the explored variables are not integrated at the level while the findings showed that the variables of the tested model are stationary at the first-difference process. The outcomes show $\mathrm{lnCO_2}$, lnOP, lnGE, lnT, lnGDP , $\mathrm{lnGDP^2}$, L nREC, and lnNREC variables have I(1) integration order. Therefore, the tested model, as presented, is acceptable to test the level of co-integration. Furthermore, **Table 3** shows some economic fluctuations in Turkey over the tested period, such as the 2001 crisis and 2008 crisis.

The B-ARDL (McNown et al., 2018) co-integration test outcomes are displayed in **Table 4**. The outcomes of B-ARDL indicate that the values of F/*Pesaran*, T /*dependent*, and F /*dependent* exceed the B-ARDL CV. The outcomes approve that the hypothesis (H0) of no co-integration at the 5% significance level is rejected because the estimated statistics values of F/*Pesaran*, T /*dependent*, and F /*dependent* in the B-ARDL test of co-integration exceeded the 5% CV. Hence, B-ARDL (McNown et al., 2018) outcomes provided strong empirical evidence to confirm that the level of co-integration between studied variables is valid.

The coefficients of tested variables are estimated using the following models: the ARDL, FM-OLS, D-OLS, and CCR models. The long-term coefficients from the ARDL testing model displayed in **Table 5** and the long-run outcomes from the ARDL testing model illustrate that the coefficient of government expenditures is positively and significantly linked with carbon emissions. If the government expenditures increased 1%, CO_2 emissions will increase by 0.04%. In addition, the findings show that the coefficient of taxation revenues is negatively and significantly linked with the levels of CO_2 emissions. A 1% increase in taxation revenues decreases CO_2 emissions by 0.13%. On the other hand, the findings show that the coefficient of per capita GDP is positively and significantly linked to emission levels. A one percent increase in per capita GDP increases CO_2 emissions by 2.96%, while the coefficient of GDP^2 is negatively and significantly linked with carbon levels. A 1% rise in per capita GDP^2 decreases CO_2 emissions by 0.55%. Furthermore, the coefficient of NREC is positively and significantly linked with the levels of emissions. A 1% increase in NREC/per capita raises CO_2 emissions by 0.88%, while the coefficient of REC is negatively and significantly linked

TABLE 2 | The outcomes of the Perron–Vogelsang unit roots test

	At Level			At Δ	
Variables	*t/stat*	BD	Variables	*t/stat*	BD
$lnCO_2$	−1.57	2001	$\Delta lnCO_2$	−7.32[a]	2008
lnOP	−2.00	2008	*ΔlnOP*	−7.99[a]	2013
lnGE	−2.11	2001	*ΔlnGE*	−7.31[a]	2009
lnT	−3.51	2002	*ΔlnT*	−6.18[a]	2012
lnGDP ($lnGDP^{.2}$)	−2.97	1994	ΔlnGDP ($lnGDP^{.2}$)	−7.11[a]	2008
lnREC	−2.33	2004	*ΔlnREC*	−7.45[a]	2009
lnNREC	−3.51	1999	*ΔlnNREC*	−7.00[a]	2011

[a]*Means statistical significance at the 5% level, BD is the break-date*

TABLE 3 | The outcomes of Zivot/Andrews unit roots test.

	At Level			At Δ	
Variables	***t/stat***	**BD**	**Variables**	***t/stat***	**BD**
$lnCO_2$	−2.71	1990	Δ $lnCO_2$	−6.01[a]	2001
lnOP	−2.19	1997	ΔlnOP	−6.01[a]	2010
lnGE	−1.38	2011	lnGE	−6.44[a]	2014
lnT	−1.38	2011	ΔlnT	−7.01[a]	2014
lnGDP /$lnGDP^{.2}$	−1.10	2001	ΔlnGDP /$lnGDP^{.2}$	−6.30[a]	2009
Ln REC	−2.15	1998	ΔlnREC	−7.11[a]	2005
lnNREC	−3.20	2011	ΔlnNREC	−5.99[a]	2008

[a]*Means statistical significance at the 5% level, BD is break-date*

with emission levels. A 1% raise in REC decreases CO_2 emissions by 0.04%. Finally, the results show that the coefficient of the oil price is negatively and significantly linked with carbon emissions. A 1% increase in the oil price decrease CO_2 emissions by 0.03%.

The long-run results from FMOLS, CCR, and DOLS testing models are displayed in **Table 6**. The findings from FMOLS and CCR show that the coefficients of government expenditures are positively and significantly linked with carbon emissions. However, the coefficients from FMOLS and CCR models confirmed the ARDL findings in the long run and provided strong evidence that there is a positive linkage between government expenditures and Turkey's CO_2 emissions. In addition, the findings from FMOLS, CCR, and DOLS testing models show that the coefficients of taxation revenues are negatively and significantly linked with the level of environmental degradation. However, the coefficients of taxation revenues in FMOLS, CCR, and DOLS models confirmed the ARDL testing results in the long run and provided strong evidence that there is a negative linkage

TABLE 5 | Long-run coefficients in ARDL testing model

Variable	Coefficient	t-Statistic	Prob.
lnOP	−0.039*	−0.987	0.060
lnGE	0.049**	1.093	0.001
lnT	−0.136**	−1.493	0.029
lnGDP	2.966***	5.706	0.003
$lnGDP^2$	−0.556***	−1.957	0.001
lnREC	−0.045*	−0.895	0.084
lnNREC	0.880***	3.439	0.000

*Note: *, **, and *** signalize significance of variables at 10, 5, and 1% level, respectively.*

between taxation revenues and Turkey's CO_2 emissions. These results are in line with those of Katircioglu and Katircioglu (2018), who used the ARDL testing model and tested the influence of government expenditures and tax revenues on the level of environmental pollution in Turkey. The outcomes indicated that there is a negative and significant interaction amongst taxation revenues and CO_2 emissions over the investigated period.

On the other hand, the findings of FMOLS, CCR, and DOLS testing models show that the coefficients of GDP are positively and significantly linked to emission levels, while the coefficients of GDP^2 negatively and significantly linked with CO_2 emission. In this regard, the findings from ARDL, FMOLS, CCR, and DOLS testing models provide strong evidence that the coefficients of GDP are positive and those of GDP^2 are negative. In this regard, the outcomes illustrate that the EKC is accepted in the case of Turkey. It means carbon emissions will increase in the first stage of economic growth. But after a specific period, an increase in the economic development would result in decreases in the level of CO_2 emissions. These outcomes align with those of Altarhouni et al. (2021), who affirmed that the ECK-H is valid in Turkey.

Furthermore, the coefficients of NREC from FMOLS, DOLS, and CCR are positively and significantly linked with the levels of emissions. These outcomes are in line with those of Alola and Donve, (2021), who affirmed that NREC positively influences carbon emission in Turkey over the period from 1965 to 2014, while the coefficients of REC in FMOLS and CCR are negatively and significantly linked with emission levels. These outcomes are in line with those of Magazzino (2016) and Altarhouni et al. (2021), who affirmed that REC negatively affected the level of environmental pollution in Turkey. Finally, the outcomes illustrate that the coefficient of the oil price is negatively linked with CO_2 emissions. The findings from ARDL, FMOLS, CCR, and DOLS testing models provide strong evidence that the

TABLE 4 | The results of the B-ARDL approach

ARDL)1,1,1,0,1,1)		$F_{Pesaran}$	$t_{dependent}$	$F_{independent}$
(CO_2, GE, T, OP, GDP, GD P^2, REC, NREC)		6.51***	−3.39***	7.81***
CV at 1,5, and10 levels	1%	3.85	−3.85	7.02
	5%	3.15	−3.15	4.80
	10%	2.81	−2.81	3.82

****statistical significance at 1% level*

TABLE 6 | FMOLS, DOLS, and CCR testing models

Variable	FMOLS	DOLS	CCR.
lnOP	−0.078***	−0.074**	−0.064**
lnGE	0.017*	0.491	0.011*
lnT	−0.257**	−0.179*	−0.231**
lnGDP	2.997***	2.334***	2.966***
$lnGDP^2$	−0.560**	−0.508*	−0.795***
lnREC	−0.045*	−0.001	−0.041*
lnNREC	1.261**	1.152*	1.136**
R	0.96	0.95	0.96

*Note: *, **, and *** signalize significance of variables at 10, 5, and 1% level, respectively.*

TABLE 7 | The results of the ARDL testing model in short-run.

Variable	Coefficient	t-Statistic	Prob.
ΔlnOP	−0.027***	−3.01	0.0092
ΔlnGE	−0.013***	−2.01	0.0092
ΔlnT	−0.034***	−3.76	0.0021
ΔlnGDP	3.1621***	5.54	0.0006
$ΔlnGDP^2$	−0.701***	−1.13	0.0000
ΔlnREC	−0.196**	−2.16	0.0479
ΔlnREC	1.075***	2.63	0.0000
ECT_{t-1}	−0.90***	−6.56	0.0000

*Note: *, **, and *** signalize significance level of variables at 10, 5, and 1% level, respectively.*

coefficients of the oil price negatively affected the level of environmental degradation in Turkey over the selected period. These outcomes are consistent with those of Abumunshar et al. (2020), who employed the ARDL testing approach and approved that oil price negatively affected the levels of carbon emissions in Turkey. The outcome of ECM is negative and significant (**Table 7**). This finding EMC is −0.90, which indicates that any deviation from the long-run equilibrium is adjusted and corrected by 90% each tested year. **Figure 3** shows the linkage among the variables.

Table 8 shows the outcomes of the diagnostic tests; the findings of the Normality$-^{test}$ demonstrate that the explored model of the current study has a normal distribution. In addition, the findings of the ARCH$-^{test}$, LM$-^{test}$, Heteroscedasticity $-^{test}$, and $Ramsey-^{test}$ affirm the absence of the auto-correlation in the explored model, and this model is correct and stable. **Figure 4** shows the (CUSUM) and (CUSUM-Q) tests. The figure affirms that the tested model of this study is correct and stable.

The values of $t - statistics$ of the ECT show that the long-run causal linkage amongst test variables (OP, GE, T, GDP, GD P^2, REC, NREC→ CO_2) is valid. Besides, the findings show (F) statistics values (**Table 9**) confirm the causal link from the oil price, government expenditures, taxation revenues, economic growth, REC, and NREC to the levels of carbon emissions in Turkey (OP, GE, T, GDP, GD P^2, REC, and NREC→ CO_2). Moreover, there is a causal link between OP→T, GDP, and NREC. The empirical outcomes of this study affirm that oil prices have a significant impact on the levels of Turkey's environmental pollution through taxation revenues, nonrenewable energy consumption, and GDP factors. However, despite that renewable energy resources have several advantages, such as zero carbon emissions, and they can be renewed; the level of NREC in Turkey has increased consistently over the last decades. In this sense, Turkey's gas consumption has risen from less than one billion cubic feet in 1981 to around 1,600 billion cubic feet in 2015. The coal consumption rose from 20 million tons in 1981 to 86 million tons in 2015. The consumption of oil in Turkey has risen from around 314,000 (barrels per day) in 1981 to around 941,000 (barrels per day) in 2015. Turkey is one of the leading producers of construction materials, electronics, cars, electronics appliances, and other equipment in the world, which in turn led to increasing the levels of fossil fuels consumption. However, Turkey imports more than 50% of the energy needs from other countries. Hence, fluctuations in oil prices have a significant influence on economic performance. Subsequently, it will affect the levels of oil, gas, and coal energy consumption. Hence, the current research suggests that the oil price has a powerful influence on consumers' ability. An increase in the oil price may postpone their equipment purchases that use (fossil fuel). Subsequently, it may lead to a decline in the demand level of equipment, capital goods, and consumer durables, leading to decreased real income and fossil fuel energy consumption.

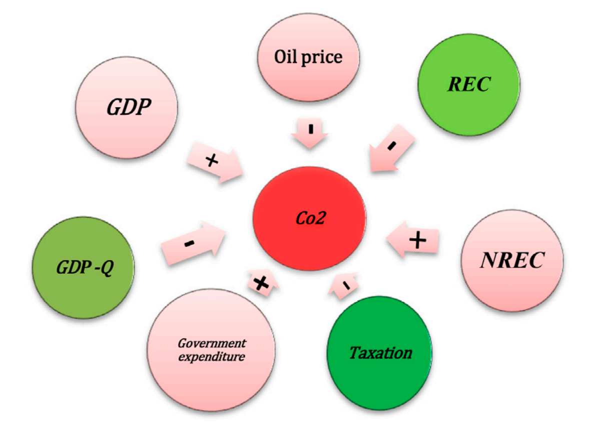

FIGURE 3 | Shows the linkage among the variables.

TABLE 8 | The outcomes of Diagnostic tests

TEST	*p*-value
LM $-^{test}$	0.315(0.215)
Heteroscedasticity $-^{test}$	1.421(0.650)
Normality$-^{test}$	0.965(0.345)
ARCH$-^{test}$	1.410(0.315)
$Ramsey-^{test}$	1.001(0.312)

Moreover, a significant change in oil prices may affect consumer options by shifting their consumption from oil sources to renewable energy sources such as solar sources. Hence, the level of REC will increase, and consumption of oil, gas, and coal will decrease, which in turn will lead to a decrease in

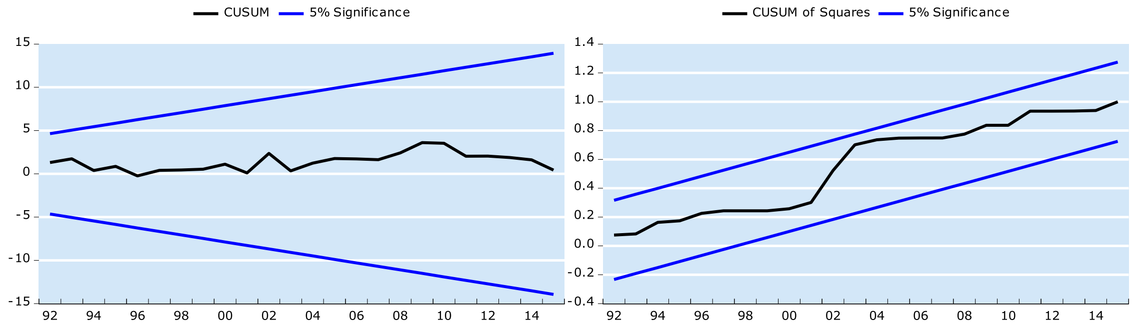

FIGURE 4 | Stability test using (CUSUM) and (CUSUMQ).

TABLE 9 | Outcomes of Granger-causality approach

(Y/X)	ΔlnCO$_2$	ΔlnOP	ΔlnT	ΔlnGE	ΔlnGDP	ΔlnGDP^2	ΔlnREC	ΔlnNREC	ECTt – 1
ΔlnCO$_2$	-	7.12**	7.99*	6.15*	6.01*	1.99	8.1**	9.10**	–0.410**
ΔlnOP	1.11	-	1.001	1.33	2.00	1.53	1.14	0.59	–0.210
ΔlnGE	2.07	7.09**	-	2.19	8.15	2.01	1.11	2.92	–0.210
ΔlnTR	1.91	8.10**	1.91	-	1.11	2.99	2.74	1.08	–0.345
ΔlnGDP	1.26	6.11*	3.11	3.11	-	1.46	3.11	2.88	–0.311
ΔlnGDP^2	1.99	4.01	1.99	1.3	3.01	-	2.67	2.23	–0.647
ΔlnNREC	2.49	3.01	2.44	2.11	2.22	2.04	-	1.31	–0.352
ΔlnNREC	0.65	6.01*	0.31	0.65	8.91**	4.64	1.77	-	–0.329

*Note: * and ** denote significance at 1 and 5% levels.*

the levels of CO_2 emissions. As mentioned earlier, the study showed the oil price has a significant impact on CO_2 emissions through fiscal policy channels. In this context, the study suggests that the policymakers in Turkey should design policies to avert any undesirable effects of oil price volatilities on the environment using fiscal policy channels. In this sense, the government should design a framework that includes financial incentives such as low taxation rates. For instance, the tax rates on renewable energy investment should be reduced, which leads to a decrease in the level of environmental degradation.

CONCLUSION

The current study explores the influence of oil price, fiscal policy, REC, NREC, and GDP on the levels of Turkey's carbon emissions over the investigated period 1981–2015. Several empirical studies have evaluated the impact of oil prices on the environmental quality. However, the possible influence of oil prices on carbon emissions through fiscal policy channels has been ignored. For this purpose, the study aims to present a new perspective to the literature by exploring the effect of oil price on the level of carbon through the fiscal policy channel. Furthermore, the current research uses a novel co-integration technique of ARDL, as presented by (McNown et al., 2018), to examine the tested variables. The new technique of the ARDL approach is preferred over other co-integration techniques due to its advantage in estimating while addressing the statistical issues of size weakness. The FMOLS, DOLS, CCR, and ARDL testing models are utilized to examine the long-run linkage among the selected variables.

The findings from estimating models demonstrated that government expenditures positively affected environmental degradation in Turkey. In contrast, the taxation revenues affected the environmental degradation negatively from 1981 to 2015. Moreover, the outcomes of this research from four estimating models show that the GDP coefficients are positive, and the coefficients of GDP square are negative. These outcomes approved that the EKC is accepted in Turkey. Moreover, the findings show that the coefficients of nonrenewable energy are positively and statistically significant in the estimating models, while the results confirm that increased renewable energy would result in the decreased levels of CO_2 emissions. Finally, the findings from estimating testing models provide strong evidence that the coefficients of the oil price negatively affected carbon emissions over the tested period. Over the recent decades, the levels of carbon emission in Turkey have increased significantly, placing Turkey among the top 20 highest GHG emitters globally. Moreover, it is noteworthy that Turkey is mindful that the rise in the number of global emissions of GHGs presents a danger to humanity's future. On the other hand, Turkey imports more than 50% of the energy needed. In this context, the current study demonstrates a series of significant outcomes and policy implications. First, the main conclusion of this study is that oil prices have a powerful effect on the levels of environmental pollution through taxation revenues and nonrenewable energy consumption GDP factors. This conclusion can be explained that Turkey, as an oil imported economy, relies almost entirely on imports. Hence, any fluctuations in oil prices have a powerful influence on the economic performance in Turkey, which in turn affects the tax revenues and government expenditures. Subsequently, this change will affect the level of energy consumption and carbon emissions; it suggested that Turkey reduce the rate of oil imports by adding more green energy sources for the energy mix to avert any undesirable effect of oil prices on the environment. Second, the Turkish policymakers should design new policies to improve the environmental quality by increasing the energy efficiency and adding more clean energy sources to the energy formula.

These policies may improve the environmental quality in Turkey, but they will lead to limiting its dependency on foreign suppliers of fossil fuel energy. In addition, Turkey should design new green economics policies to limit the negative impact of income on the environmental quality. Third, the study shows that taxation revenues have a significant impact on improving the environmental quality. It is noteworthy that Turkey is mindful that the rise in the number of global emissions of GHGs presents a danger to humanity's future and that this situation significantly affects developing countries. For different reasons, fiscal and other financial incentives may be appropriate and efficient tools, in particular, to promote the production and implementation of new technology and to encourage investments in green energy conservation. Such incentives, however, must be structured to mitigate carbon emissions. The carbon tax policy is one of the most efficient tools to reduce the level of CO_2 emissions but only if these tools are implemented in a growth-friendly manner. As an emerging economy, Turkey does not operate an emission trading system for carbon emissions and does not have carbon taxes. In this context, this study's main significant recommendation is that Turkey uses the carbon tax policy to improve the environmental quality. Furthermore, Turkish policymakers should design policies to avoid any undesirable impacts of the spillover effects of the oil price on the environment using fiscal policy channels. For instance, promoting green investment by low tax rates. Future empirical studies should be devoted to investigating the long-term linkages between different sectors of the economy and environmental quality using different panel methods.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://data.worldbank.org/.

AUTHOR CONTRIBUTIONS

OH: engaged at all stages to participate in the writing of the manuscript. AS: project administration, supervision, methodology, and writing-original draft; MA: formal analysis and writing-original draft preparation, and investigation; LA: supervision and project administration. MO: writing-original draft. TT: finally, as a head read and adjusted the manuscript to be suitable for publication.

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REFERENCES

Abumunshar, M., Aga, M., and Samour, A. (2020). Oil Price, Energy Consumption, and CO2 Emissions in Turkey. New Evidence from a Bootstrap ARDL Test. *Energies* 13 (21), 5588. doi:10.3390/en13215588

Adewuyi, A. O. (2016). Effects of Public and Private Expenditures on Environmental Pollution: A Dynamic Heterogeneous Panel Data Analysis. *Renew. Sust. Energ. Rev.* 65, 489–506. doi:10.1016/j.rser.2016.06.090

Ali, S., Can, M., Shah, M. I., Jiang, J., Ahmed, Z., and Murshed, M. (2022). Exploring the Linkage between export Diversification and Ecological Footprint: Evidence from Advanced Time Series Estimation Techniques. *Environ. Sci. Pollut. Res.*, 1–15. doi:10.1007/s11356-022-18622-3

Alola, A. A., and Donve, U. T. (2021). Environmental Implication of Coal and Oil Energy Utilisation in Turkey: Is the EKC Hypothesis Related to Energy? *Manag. Environ. Qual. Int. J.* 32 (3), 543–559. doi:10.1108/meq-10-2020-0220

Altarhouni, A., Danju, D., and Samour, A. (2021). Insurance Market Development, Energy Consumption, and Turkey's CO2 Emissions. New Perspectives from a Bootstrap ARDL Test. *Energies* 14 (23), 7830. doi:10.3390/en14237830

Altıntaş, H., and Kassouri, Y. (2020). Is the Environmental Kuznets Curve in Europe Related to the Per-Capita Ecological Footprint or CO2 Emissions? *Ecol. Indicators* 113, 106187. doi:10.1016/j.ecolind.2020.106187

Anwar, M. A., Zhang, Q., Asmi, F., Hussain, N., Plantinga, A., Zafar, M. W., et al. (2022). Global Perspectives on Environmental Kuznets Curve: A Bibliometric Review. *Gondwana Res.* 103, 135–145. doi:10.1016/j.gr.2021.11.010

Apergis, N., and Payne, J. E. (2015). Renewable Energy, Output, Carbon Dioxide Emissions, and Oil Prices: Evidence from South America. *Energ. Sourc. B: Econ. Plann. Pol.* 10 (3), 281–287. doi:10.1080/15567249.2013.853713

Bernauer, T., and Koubi, V. (2006). States as Providers of Public Goods: How Does Government Size Affect Environmental Quality? *SSRN Electron. J.*, 900487. doi:10.2139/ssrn.900487

Bilgili, F., Koçak, E., and Bulut, Ü. (2016). The Dynamic Impact of Renewable Energy Consumption on CO 2 Emissions: A Revisited Environmental Kuznets Curve Approach. *Renew. Sust. Energ. Rev.* 54, 838–845. doi:10.1016/j.rser.2015.10.080

Chen, W., and Geng, W. (2017). Fossil Energy Saving and CO2 Emissions Reduction Performance, and Dynamic Change in Performance Considering Renewable Energy Input. *Energy* 120, 283–292. doi:10.1016/j.energy.2016.11.080

Dogan, E., and Ozturk, I. (2017). The Influence of Renewable and Non-renewable Energy Consumption and Real Income on CO2 Emissions in the USA:

Evidence from Structural Break Tests. *Environ. Sci. Pollut. Res.* 24 (11), 10846–10854. doi:10.1007/s11356-017-8786-y

Fatima, T., Shahzad, U., and Cui, L. (2020). Renewable and Nonrenewable Energy Consumption, Trade and CO2 Emissions in High Emitter Countries: Does the Income Level Matter? *J. Environ. Plann. Manag.* 64 (0), 1227–1251. doi:10.1080/09640568.2020.1816532

Frederik, C., and Lundström, S. (2001). *Political and Economic freedom and the Environment: The Case of CO2 Emissions*. Gothenburg City: Department of Economics, Göteborg University.

Ghazouani, A., Xia, W., Ben Jebli, M., and Shahzad, U. (2020). Exploring the Role of Carbon Taxation Policies on CO2 Emissions: Contextual Evidence from Tax Implementation and Non-implementation European Countries. *Sustainability* 12 (20), 8680. doi:10.3390/su12208680

Ghazouani, T. (2021). *Impact of FDI Inflow, Crude Oil Prices, and Economic Growth on CO2 Emission in Tunisia: Symmetric and Asymmetric Analysis through ARDL and NARDL Approach*.

Grossman Gene, M., and Krueger, A. B. (1993). *Environment Impacts of a North American Free Trade Agreement*. Mexico City: The U SMexico Free Trade Agreement.

Halkos, G. E., and Paizanos, E. A. (2013). The Effect of Government Expenditure on the environment:An Empirical Investigation. *Ecol. Econ.* 91, 48–56. doi:10.1016/j.ecolecon.2013.04.002

Haque, M. I. (2020). Oil price Shocks and Energy Consumption in GCC Countries: a System-GMM Approach. Environment, Development, and Sustainability. 116, Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Eurasia/Turkey_Eurasia_RE_SP.pdf (last access date June 10, 2021).

Jobert, T., and Karanfil, F. (2007). Sectoral Energy Consumption by Source and Economic Growth in Turkey. *Energy Policy* 35 (11), 5447–5456.

Katircioglu, S., and Katircioglu, S. (2018). Testing the Role of Fiscal Policy in the Environmental Degradation: the Case of Turkey. *Environ. Sci. Pollut. Res.* 25 (6), 5616–5630. doi:10.1007/s11356-017-0906-1

Koengkan, M., Fuinhas, J. A., and Santiago, R. (2020). The Relationship between CO2 Emissions, Renewable and Non-renewable Energy Consumption, Economic Growth, and Urbanisation in the Southern Common Market. *J. Environ. Econ. Pol.* 9 (4), 383–401. doi:10.1080/21606544.2019.1702902

Leal, P. H., and Marques, A. C. (2020). Rediscovering the EKC Hypothesis for the 20 Highest CO2 Emitters Among OECD Countries by Level of Globalization. *Int. Econ.* 164, 36–47. doi:10.1016/j.inteco.2020.07.001

Li, K., Fang, L., and He, L. (2019). How Population and Energy price Affect China's Environmental Pollution? *Energy Policy* 129, 386–396. doi:10.1016/j.enpol.2019.02.020

Li, K., Fang, L., and He, L. (2020). The Impact of Energy price on CO2 Emissions in China: a Spatial Econometric Analysis. *Sci. Total Environ.* 706, 135942. doi:10.1016/j.scitotenv.2019.135942

Magazzino, C. (2016). The Relationship Among Real GDP, CO2 Emissions, and Energy Use in South Caucasus and Turkey. *Int. J. Energ. Econ. Pol.* 6 (4), 672–683.

Mahmood, H., and Murshed, M. (2021). Oil price and Economic Growth Nexus in Saudi Arabia: Asymmetry Analysis. *Int. J. Energ. Econ. Pol.* 11 (1), 29. doi:10.32479/ijeep.11181

Malik, M. Y., Latif, K., Khan, Z., Butt, H. D., Hussain, M., and Nadeem, M. A. (2020). Symmetric and Asymmetric Impact of Oil price, FDI and Economic Growth on Carbon Emission in Pakistan: Evidence from ARDL and Non-linear ARDL Approach. *Sci. Total Environ.* 726, 138421. doi:10.1016/j.scitotenv.2020.138421

McNown, R., Sam, C. Y., and Goh, S. K. (2018). Bootstrapping the Autoregressive Distributed Lag Test for Cointegration. *Appl. Econ.* 50 (13), 1509–1521. doi:10.1080/00036846.2017.1366643

Mensah, I. A., Sun, M., Gao, C., Omari-Sasu, A. Y., Zhu, D., Ampimah, B. C., et al. (2019). Analysis on the Nexus of Economic Growth, Fossil Fuel Energy Consumption, CO2 Emissions and Oil price in Africa Based on a PMG Panel ARDL Approach. *J. Clean. Prod.* 228, 161–174. doi:10.1016/j.jclepro.2019.04.281

Minlah, M. K., and Zhang, X. (2021). Testing for the Existence of the Environmental Kuznets Curve (EKC) for CO2 Emissions in Ghana: Evidence from the Bootstrap Rolling Window Granger Causality Test. *Environ. Sci. Pollut. Res.* 28 (2), 2119–2131. doi:10.1007/s11356-020-10600-x

Namahoro, J. P., Wu, Q., Zhou, N., and Xue, S. (2021). Impact of Energy Intensity, Renewable Energy, and Economic Growth on CO2 Emissions: Evidence from Africa Across Regions and Income Levels. *Renew. Sustain. Energy Rev.* 147, 111233.

Nathaniel, S., Nwodo, O., Adediran, A., Sharma, G., Shah, M., and Adeleye, N. (2019). Ecological Footprint, Urbanization, and Energy Consumption in South Africa: Including the Excluded. *Environ. Sci. Pollut. Res.* 26 (26), 27168–27179. doi:10.1007/s11356-019-05924-2

Nwani, C. (2017). Causal Relationship between Crude Oil price, Energy Consumption and Carbon Dioxide (CO2) Emissions in Ecuador. *OPEC Energ. Rev* 41 (3), 201–225. doi:10.1111/opec.12102

Ocal, O., and Aslan, A. (2013). Renewable Energy Consumption-Economic Growth Nexus in Turkey. *Renew. Sustain. Energ. Rev.* 28, 494–499. doi:10.1016/j.rser.2013.08.036

Olamide, E., and Maredza, A. (2021). The Short and Long Run Dynamics of Monetary Policy, Oil Price Volatility and Economic Growth in the CEMAC Region. *Asian Econ. Financial Rev.* 11 (1), 78–89. doi:10.18488/journal.aefr.2021.111.78.89

Pao, H.-T., Yu, H.-C., and Yang, Y.-H. (2011). Modeling the CO2 Emissions, Energy Use, and Economic Growth in Russia. *Energy* 36 (8), 5094–5100. doi:10.1016/j.energy.2011.06.004

Paramati, S. R., Shahzad, U., and Doğan, B. (2022). The Role of Environmental Technology for Energy Demand and Energy Efficiency: Evidence from OECD Countries. *Renew. Sust. Energ. Rev.* 153 (January 2021), 111735. doi:10.1016/j.rser.2021.111735

Park, J. Y. (1992). Canonical Cointegrating Regressions. *Econometrica* 60, 119–143. doi:10.2307/2951679

Perron, P., and Vogelsang, T. J. (1993). A Note on the Asymptotic Distributions of Unit Root Tests in the Additive Outlier Model with Breaks. *Braz. Rev. Econom.* 13 (2), l8l–20l. doi:10.12660/bre.v13n21993.2981

Pesaran, M. H., Shin, Y., and Smith, R. J. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *J. Appl. Econ.* 16 (3), 289–326. doi:10.1002/jae.616

Phillips, P. C. B., and Hansen, B. E. (1990). Statistical Inference in Instrumental Variables Regression with I(1) Processes. *Rev. Econ. Stud.* 57 (1), 99–125. doi:10.2307/2297545

Qashou, Y., Samour, A., and Abumunshar, M. (2022). Does the Real Estate Market and Renewable Energy Induce Carbon Dioxide Emissions? Novel Evidence from Turkey. *Energies* 15 (3), 763.

Rafique, M. Z., Nadeem, A. M., Xia, W., Ikram, M., Shoaib, H. M., and Shahzad, U. (2021). Does Economic Complexity Matter for Environmental Sustainability? Using Ecological Footprint as an Indicator. *Environ. Dev. Sustain.*, 0123456789. doi:10.1007/s10668-021-01625-4

Rahman, S., and Serletis, A. (2019). Oil Prices and the Stock Markets: Evidence from High Frequency Data. *Energ. J.* 40 (Special Issue). doi:10.5547/01956574.40.si2.srah

Samour, A., Baskaya, M. M., and Tursoy, T. (2022). The Impact of Financial Development and FDI on Renewable Energy in the UAE: A Path towards Sustainable Development. *Sustainability* 14 (3), 1208. doi:10.3390/su14031208

Shafiei, S., and Salim, R. A. (2014). Non-renewable and Renewable Energy Consumption and CO2 Emissions in OECD Countries: A Comparative Analysis. *Energy Policy* 66, 547–556. doi:10.1016/j.enpol.2013.10.064

Shahbaz, M., and Sinha, A. (2019). Environmental Kuznets Curve for CO2 Emissions: a Literature Survey. *J. Econ. Stud.* doi:10.1108/jes-09-2017-0249

Shahzad, U., Ferraz, D., Nguyen, H.-H., and Cui, L. (2022). Investigating the Spill Overs and Connectedness between Financial Globalization, High-Tech Industries and Environmental Footprints: Fresh Evidence in Context of China. *Technol. Forecast. Soc. Change* 174 (2), 121205. doi:10.1016/j.techfore.2021.121205

Stock, J. H., and Watson, M. W. (1993). A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems. *Econometrica* 61, 783–820. doi:10.2307/2951763

Su, C.-W., Huang, S.-W., Qin, M., and Umar, M. (2021). Does Crude Oil price Stimulate Economic Policy Uncertainty in BRICS? *Pacific-Basin Finance J.* 66, 101519. doi:10.1016/j.pacfin.2021.101519

Suleiman, A., Bsisu, I., Guzu, H., Santarisi, A., Alsatari, M., Abbad, A., .Jaber, A., Harb, T. a., Abuhejleh, A., Nadi, N., Aloweidi, A., and Almustafa, M.

(2020). Preparedness of Frontline Doctors in Jordan Healthcare Facilities to COVID-19 Outbreak. *Ijerph* 17 (9), 3181. doi:10.3390/ijerph17093181

Wang, Z., Ben Jebli, M., Madaleno, M., Doğan, B., and Shahzad, U. (2021). Does export Product Quality and Renewable Energy Induce Carbon Dioxide Emissions: Evidence from Leading Complex and Renewable Energy Economies. *Renew. Energ.* 171, 360–370. doi:10.1016/j.renene.2021.02.066

Wolde-Rufael, Y., and Mulat-Weldemeskel, E. (2021). Do environmental Taxes and Environmental Stringency Policies Reduce CO 2 Emissions? Evidence from 7 Emerging Economies. *Environ. Sci. Pollut. Res.* 28 (18), 22392–22408. doi:10.1007/s11356-020-11475-8

Xia, W., Apergis, N., Bashir, M. F., Ghosh, S., Doğan, B., and Shahzad, U. (2022). Investigating the Role of Globalization, and Energy Consumption for Environmental Externalities: Empirical Evidence from Developed and Developing Economies. *Renew. Energ.* 183, 219–228. doi:10.1016/j.renene.2021.10.084

Yuelan, P., Akbar, M. W., Hafeez, M., Ahmad, M., Zia, Z., and Ullah, S. (2019). The Nexus of Fiscal Policy Instruments and Environmental Degradation in China. *Environ. Sci. Pollut. Res.* 26 (28), 28919–28932. doi:10.1007/s11356-019-06071-4

Zhao, Y., Zhang, Y., and Wei, W. (2021). Quantifying International Oil price Shocks on Renewable Energy Development in China. *Appl. Econ.* 53 (3), 329–344. doi:10.1080/00036846.2020.1808173

Zivot, E., and Andrews, D. W. K. (2002). Further Evidence on the Great Crash, the Oil-price Shock, and the Unit-Root Hypothesis. *J. Business Econ. Stat.* 20 (1), 25–44. doi:10.1198/073500102753410372

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