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Do natural resources heal the environment? Empirical evidence from Turkey

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Abstract

The increase in environmental degradation has rapidly enhanced the interest in the main determinants of CO_2 emissions. Although many attempts have been exerted to discover the determinants of CO_2 emissions, the impact of natural resources (NAT), which have significant environmental impacts on CO_2 emissions, has been considerably neglected. To fulfill this gap in the literature, the study analyzes the impact of NAT on CO_2 emissions covering the period 1975–2017 in Turkey. In addition, economic growth, renewable energy consumption, trade openness, and energy consumption are added in the model as explanatory variables. Findings from ARDL, FMOLS, and DOLS estimators indicate that the abundance of NAT is an important catalyst in reducing CO_2 emissions. The results denote that the EKC is valid in Turkey. Furthermore, although the total energy consumption enhances CO_2 emission, renewable energy reduces it. Thus, the increased use of NAT is important to improve the environmental quality in Turkey.

Keywords CO_2 emissions · Natural resources · Energy consumption · Turkey · ARDL method · VECM causality

Introduction

Environmental problems, such as climate change and global warming, have become several of the most crucial discussions at the global level and have started to pose a serious obstacle to sustainable development (Danish et al. 2019). The increase in carbon dioxide emissions (CO_2) is one of the most important factors behind such serious environmental problems. Growing population (POP), the rapid enhance in economic activities, and widespread consumption of fossil fuels raise the CO_2 and pose a serious threat to human existence by increasing the earth's temperature. Despite the global consensus concerning their reduction, the amount of CO_2 is gradually increasing. According to the BP (2020), the global CO_2 level was 11,193.8 million tons (mt) in 1965, and it increased by threefold in 2019 (34,169.0 mt).

Reducing CO_2 and increasing the environmental quality are strategic for sustainable development and building a harmonious society. Within the framework of this important strategy, determining the main determinants of CO_2 is important to increase the environmental quality. Therefore, research attempts to explore the key determinants of environmental degradation, particularly CO_2, have increased rapidly in recent years. In early studies, environmental degradation and CO_2 were often associated with economic growth (gross domestic product (GDP)) and energy consumption (ENE) (Balsalobre-Lorente et al. 2018). Models that explain CO_2 over time have been expanded with various economic, social, and political factors (Katircioglu et al. 2020a). In the current literature, in addition to GDP and ENE, factors, such as globalization (GLO), agriculture (AGR), tourism (TOU), trade openness (TRA), financial development (FD), foreign direct investments (FDI), POP, urbanization (URB), education (EDU), institutional quality (IQ), and income distribution (GINI), are used to disclose information on CO_2 (see the "Literature review" section). Although these studies have contributed significantly to expanding the environmental economy literature and determining the causes of CO_2, important deficiencies are still observed. In this context, the abundance of natural resources (NAT) has not been considered as a determinant of CO_2.

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First, the excessive and inefficient use of NAT through AGR, deforestation, and mining increases the depletion rate of NAT, whereas the amount of generated waste can create serious environmental problems. Especially, developing countries can allow the exploitation of NAT and loosen environmental regulations to attract relatively dirty industries in developed countries to accelerate their economic development process (Danish et al. 2019). Although the abundance of NAT has such negative effects on the environment, it also has potential effects that will increase the quality of the environment. For example, abundant NAT may reduce CO_2 by limiting the import of fossil-based energy sources, such as oil and gas (Balsalobre-Lorente et al. 2018). In this context, countries that lack NAT will meet their energy need, which is an important input for GDP, by importing fossil fuels, which will lead to an increase in CO_2. This condition is related to the employment of NAT, such as natural gas and renewable resources, which produce less emission than fossil-based energy sources. Therefore, the abundance of NAT can reduce the dependence on fossil fuel and energy intensity and allow energy policies to limit CO_2.

The increasing pressure on the government and policymakers in the face of serious environmental consequences of CO_2-induced greenhouse gas emissions has increased the share of renewable resources in the energy portfolio as a strategic choice. Therefore, the abundance of NAT can be an important catalyst in reducing CO_2 and increasing the environmental quality. On the other hand, the excessive and inefficient use of NAT can have negative environmental impacts. Therefore, the effect of the abundance of NAT on CO_2 is unclear. Failure to sufficiently define the relationship between NAT and CO_2 creates a strong motivation for researchers. In this context, the study tests the effect of NAT on CO_2 in Turkey during the period 1975 to 2017.

Turkey is a good example to examine the nexus between NAT and CO_2. According to the 2019 classification of the World Bank, Turkey, which is a high–middle income country, has achieved significant growth in the 2000s. According to World Development Indicators, the per capita income of the country in the 1990s was 7842 USD (constant 2010), and it reached almost 15,000 USD in 2018 and 2019. The increased economic activity has led to a rapid increase in ENE in Turkey. The primary ENE increased by 4.1% in 2008–2018 and rose to 6.49 exajoules in 2019 (BP 2020). Economic activities and increased ENE have led to the rapid rise of CO_2 in Turkey (Uzar and Eyuboglu 2019b). The CO_2 increased by 3.6% and reached 389 million tons in 2018. In 2019, Turkey's CO_2 decreased slightly to 383 million tons (BP 2020). Turkey relies on alternative energy sources, such as water, solar, and wind. Thus, Turkey, which has abundant NAT, can reduce CO_2 by the effective use of renewable resources. To be a high-income country, Turkey should continue its economic performance. However, sustaining GDP and the increase in ENE may lead to increased CO_2 in Turkey. Therefore, policymakers in Turkey face the dilemma of increasing GDP and reducing environmental pressures. Determining the effect of NAT, which is important for GDP growth, on CO_2 is a critical source of motivation. If the reduction of CO_2 by the abundance of NAT is confirmed, then sustaining GDP in Turkey and the reduction of CO_2 can be achieved. All these experiences make Turkey an important working area.

This study is expected to contribute to the recent literature and policymaking in Turkey. First, the study describes the special role of the abundance of NAT, which is commonly neglected when explaining CO_2. Several studies (Balsalobre-Lorente et al. 2018; Danish et al. 2019) have examined the relationship between NAT and CO_2. These studies have shown complicated results regarding the effect of NAT on CO_2. Therefore, empirical evidence from different country and regional experiences is important to demonstrate the effect of the abundance of NAT on CO_2. Second, this study differs methodologically from others. Balsalobre-Lorente et al. (2018) and Danish et al. (2019) focused on specific country groups using panel data methodology. This study focused on a single country with time-series methods. Therefore, this methodological difference guarantees that the results obtained are policy oriented. The results obtained from the panel data methodology cause difficulty in the proposal of policies for countries. Third, this study is a pioneering attempt to examine the influence of NAT on CO_2 emission in Turkey. Policymakers in Turkey face the dilemma of whether to boost GDP or reduce environmental pressures. The study findings will provide important information for the development of environmental and economic growth policies.

The remainder of the study is organized as follows: the "Introduction" section provides an outlook of Turkey in terms of GDP, CO_2, and REN. The "Literature review" section gives a review of the literature. The "Data and methodology" section explains the data and empirical methodology. The "Empirical findings" section reports the empirical findings. The "Conclusion and policy implications" section concludes the paper with policy recommendations.

Literature review

The reverse U-shaped trade-off defined by Kuznets (1955) between GDP and GINI was first integrated into the environmental economy literature by Grossman and Krueger (1991), who found similar linkages between income and environmental pollution. This approach, known as the EKC, states that in the early stages of GDP, environmental degradation has increased, and after a turning point, environmental degradation has decreased with increasing GDP. Thus, the EKC has begun to be used as an effective model for determining environmental degradation. For example, Apergis and Payne (2009) examined the validity of the EKC in 6 Central American countries. The study findings showed that the EKC is valid and ENE is a crucial determinant of CO_2. Arouri et al. (2012) tested linkages among GDP, ENE, and CO_2 in 12 the Middle East and North African countries. While the authors concluded that ENE affects CO_2 positively, they cannot find strong evidence of the validity of the EKC.

Along with studies that use GDP and ENE as the main determinants of CO_2, the number of studies that examine the determinants of CO_2 more comprehensively and focus on specific areas is increasing. For example, Shahbaz et al. (2013) investigated the impact of TRA on CO_2 in South Africa for the period 1965–2008. They explored that TRA is a factor that reduces CO_2. Apergis and Ozturk (2015) included the POP into the CO_2 model in 14 Asian countries covering the period 1990–2011. GMM results indicated that POP enhances CO_2. Ali et al. (2019) analyzed the impact of URB on CO_2 in Pakistan covering the period 1972–2014. In the study, it was concluded that URB increases CO_2. Katircioglu et al. (2020a) analyzed the impact of EDU on CO_2 in Northern Cyprus covering the period 1979–2014. They found that EDU activities enhance CO_2. Katircioglu et al. (2020b) analyzed the impact of the TOU on CO_2 in Cyprus. The findings denote that TOU has positive effect on CO_2. Yang et al. (2020) used the financial instability variable to explain CO_2. In the study, in which 54 developing countries were analyzed from 1980 to 2016, it was concluded that financial instability negatively affected CO_2. Rehman et al. (2020) used agricultural production as the main explanatory variable as a determinant of CO_2. In the study covering the period of 1988–2017, it was concluded that maize crop production positively affected CO_2 in Pakistan. Wang and Zhang (2020) examined the determinants of CO_2 from transport in China. It has been determined that private vehicle ownership, technological innovation, and industrial structure have positive correlations with CO_2.

Although there are extensive studies in the literature that examine the determinants of CO_2, there are still some shortcomings. The numbers of studies analyzing the abundance of NAT, which may have potentially positive and negative effects especially on CO_2, are very few. Moreover, the results indicate that there is no consensus between NAT and CO_2. For example, Balsalobre-Lorente et al. (2018) included NAT in the study in which the European Union 5 countries examined the determinants of CO_2 during the period 1985–2016. They concluded that the abundance of NAT helps to reduce CO_2. Danish et al. (2019) tested the impact of NAT abundance on CO_2 in BRICS countries for the period 1990–2015. Findings denote that the abundance of NAT decreases CO_2 in Russia and increases it in South Africa. In other countries, no significant relationship has been detected. Hassan et al. (2019) investigated the trade-off between NAT and ecological footprint in Pakistan covering the period 1970–2014. It is determined that the abundance of NAT positively affects the ecological footprint and increases environmental erosion.

Many studies examined the main determinants of CO_2 in Turkey. For example, Halicioglu (2009) examined the relationship among TRA, ENE, and CO_2 in Turkey. Study findings have pointed out that the EKC is valid in Turkey and showed that ENE and TRA are important determinants of CO_2. Boluk and Mert (2015) investigated the effect of REN on CO_2 for Turkey. According to the findings, the EKC hypothesis is valid and REN reduces CO_2. Seker et al. (2015) found that FDI has a positive effect on CO_2 during the period 1974–2010 in Turkey. Gokmenoglu and Sadeghieh (2019) used FD to explain CO_2 in Turkey. They found that FD negatively affects CO_2. Uzar and Eyuboglu (2019a) analyzed the trade-off among GINI and CO_2 in Turkey for the period 1984–2014. They found strong evidence that the improvements in GINI reduce CO_2. Eyuboglu and Uzar (2020) tested the impact of TOU on CO_2 during the period 1960–2014 in Turkey. The findings indicated that TOU enhances CO_2. Uzuner et al. (2020) showed that GLO would be an important catalyst in reducing CO_2 in his study, which was examined in the 1970–2014 period.

Given that today's societies are facing pressures to sustain GDP growth and reduce environmental degradation, the impact of abundance of NAT on the environment is examined by a very limited number of studies. Referring in particular Turkey, although there are many attempts to explain the CO_2, no studies have existed about the analysis of the abundance of NAT. Therefore, there is a major shortcoming in the literature for Turkey. Especially when considering Turkey's unique conditions, examining the relationship between NAT abundance and CO_2 in Turkey has a significant motivation. In the framework of these unique conditions, it is conceivable that there is a negative connection between NAT and CO_2 emissions in Turkey. In the following sections, the econometric analysis will be employed to designate the validity of this hypothesis.

Data and methodology

The motivation of this study is to designate the effect of NAT on CO_2 in Turkey. Following the relevant literature, factors that may affect CO_2 are included in the model as control variables. A large number of studies investigating CO_2 have generally examined whether the EKC hypothesis is valid (Dogan and Seker 2016). In this context, to reveal the validity of the EKC, GDP per capita and the square of GDP per capita are included to model. The variables of total energy consumption (Apergis and Payne 2009; Arouri et al. 2012), renewable energy consumption (Boluk and Mert 2015), and trade openness (Halicioglu 2009; Shahbaz et al. 2013), which are widely used in the literature, are also added to our model. Thus, the main determinants of CO_2 are tried to be analyzed comprehensively. We examine annual data for Turkey from 1975 to 2017. In this context, our model to explain the CO_2 in Turkey is as follows:

$$CO_{2t} = f\left(GDP_t, GDP_t{}^2, REN_t, TRA_t, NAT_t, ENE_t\right) \quad (1)$$

In the equation, CO_2, GDP, GDP^2, REN, TRA, NAT, and ENE symbolize CO_2 emissions (million tons of carbon dioxide), GDP per capita and its squared, total renewable energy consumption (sum of wind, solar, geothermal) (million tons of oil equivalent), trade openness (sum of export and import to GDP), natural resources (total natural resources rents (% of GDP), and energy consumption (million tons oil equivalent) respectively. CO_2, REN, and ENE are taken from BP (2020). The GDP, TRA, and NAT are gathered from the World Development Indicators WDI (2020).

In this study, the ARDL approach introduced by Pesaran et al. (2001) is used to examine linkages among the variables. Unlike other cointegration approaches, the ARDL methodology allows that repressors may be stationary in levels (I(0)) or the first differenced (I(1)). The ARDL model used in this study can be expressed as follows.

$$\begin{aligned}\Delta CO_{2t} = {} & \alpha_0 + \textstyle\sum_{i=1}^{m} b_i \Delta CO_{2t-i} + \sum_{i=0}^{n} c_i \Delta GDP_{t-i} + \sum_{i=0}^{o} d_i \Delta GDP^2{}_{t-i} + \sum_{i=0}^{p} e_i \Delta REN_{t-i} \\ & + \textstyle\sum_{i=0}^{r} f_i \Delta TRA_{t-i} + \sum_{i=0}^{s} g_i \Delta NAT_{t-i} + \sum_{i=0}^{t} h_i \Delta ENE_{t-i} + \lambda_1 CO_{2t-1} + \lambda_2 GDP_{t-1} + \\ & \lambda_3 GDP^2{}_{t-1} + \lambda_4 REN_{t-1} + \lambda_5 TRA_{t-1} + \lambda_6 NAT_{t-1} + \lambda_7 ENE_{t-1} + \varepsilon_t \end{aligned} \quad (2)$$

where Δ denotes the first-difference operator, and ε is the white noise error term. The parameters b_i, c_i, d_i, e_i, f_i, g_i, and h_i are short-term coefficients and λ_s are the corresponding long-term multipliers of the ARDL model.

The null hypothesis of "no cointegration" in Eq. (2) is $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = 0$. The hypotheses are analyzed by estimating the *F*-statistics and comparing them with critical values in Pesaran et al. (2001). If the *F*-test statistic exceeds upper critical values, we can conclude that there is a long-run nexus among the variables. If the test statistic is below the upper critical value, we cannot reject the null hypothesis of no cointegration. If the estimate falls into the critical values, then the cointegration test becomes inconclusive. Given a relatively small sample size in this study of 43 observations, the critical values used are as reported by Narayan (2005) which are based on a small sample size between 30 and 80. Short-term estimation of the ARDL model is estimated in the equation below:

$$\begin{aligned}\Delta CO_{2t} = {} & \gamma_0 + \textstyle\sum_{i=1}^{a} \eta_i \Delta CO_{2t-i} + \sum_{i=0}^{b} \vartheta_i \Delta GDP_{t-i} + \sum_{i=0}^{c} \varphi_i \Delta GDP^2{}_{t-i} + \sum_{i=0}^{d} \chi_i \Delta REN_{t-i} + \\ & \textstyle\sum_{i=0}^{e} \delta_i \Delta TRA_{t-i} + \sum_{i=0}^{f} \kappa_i \Delta NAT_{t-i} + \sum_{i=0}^{g} \xi_i \Delta ENE_{t-i} + \gamma ECT_{t-i} + \mu_t \end{aligned} \quad (3)$$

The coefficient of the error-correction term *(ECT)* γ is the speed of adjustment which denotes how quickly the series attains a long-term equilibrium.

The causalities are investigated by the vector error correction model (VECM) among CO_2, GDP, REN, TRA, NAT, and ENE. The advantage of VECM lies in its strength of capturing both the short-term dynamics and long-term equilibrium relationship among the variables. The VECM representation of the model is given in Eq. 4.

$$\begin{aligned}\Delta CO_{2t} = {} & \alpha_1 + \sum_{i=1}^{n} \beta_1(i) \Delta CO_{2t-i} + \sum_{i=1}^{n} \gamma_1(i) \Delta GDP_{t-i} + \sum_{i=1}^{n} \lambda_1(i) REN\Delta_{t-i} + \sum_{i=1}^{n} \tau_1(i) \Delta TRA_{t-i} \\ & + \sum_{i=1}^{n} \varphi_1(i) \Delta NAT_{t-i} + \sum_{i=1}^{n} \sigma_1(i) \Delta ENE_{t-i} + \psi_1 ECT_{t-1} + \varepsilon_{1t} \end{aligned} \quad (4)$$

where β, γ, λ, τ, φ, and σ are the coefficients, ε_t is the usual error, and ECT is the error-correction term. If the ECT_{t-1} is the statistically significant and negative sign, it reveals long-term causality. To calculate short-term causality, we use the Wald test to differentiate and lag the difference coefficient of all independent variables. We also calculate short-term and long-term joint causality.

Empirical findings

The descriptive statistics of the variables are shown in Table 1. In the natural logarithm of the level form means of CO_2, GDP, REN, TRA, NAT, and ENE are 5.079, 8.959, 1.801, 3.555, − 0.740, and 4.059 respectively.

Besides, Fig. 1 shows scatter plot drawing of logarithmic versions of NAT and CO_2. The findings indicate that there is a negative connection between the variables. In this context, intuitive relationship between two variables in Turkey gives the signal that the use of natural resources could reduce CO_2 emissions.

Although ARDL does not require that all variables be integrated in I(1), it is crucial to explore in order to confirm that the variables are not integrated in I(2). Augmented Dickey and Fuller (1981) (ADF) and Lee and Strazicich (LS) (2003) tests are employed to determine whether there is any variable integrated with order 2 or not. The results of the ADF and LS unit root tests are presented in Table 2. All null hypotheses show there is a unit root. The result reveals that all the variables are non-stationary at their level. After differencing the variables, all the variables are confirmed to be stationary.

In the next step, we use the bound test to reveal long-term linkages between the variables. The result is reported in Table 3. The result reveals that there is cointegration among the variables in the models. In other words, bound test results indicate that CO_2, GDP, NAT, REN, TRA, and ENE move together in the long term. In this framework, there is a strong relationship between the variables. Also, the model's serial correlation, normality, heteroscedasticity tests, CUSUM, and CUSUMQ diagnostic tests show that the model is valid as reported in Table 3 and Figs. 2 and 3.

In addition, the Bayer and Hanck (2013) cointegration test is also applied to discover whether there is a long-term nexus among variables. Table 4 reports the Bayer and Hanck (2013) cointegration results. The result from the Bayer and Hanck (2013) test confirms that there is a cointegration relationship among the variables. In this context, it has been demonstrated that there are linkages among CO_2, GDP, NAT, REN, TRA, and ENE.

Table 1 The descriptive statistics

	$\ln CO_2$	lnGDP	lnREN	lnTRA	lnNAT	lnENE
Mean	5.079	8.959	1.801	3.555	− 0.740	4.059
Median	5.167	8.940	2.032	3.732	− 0.852	4.182
Maximum	5.962	9.607	2.942	4.007	0.308	5.029
Minimum	4.105	8.511	0.290	2.208	− 2.095	2.992
Std. deviation	0.540	0.326	0.692	0.449	0.576	0.592
Skewness	− 0.165	0.372	− 0.346	−1.398	− 0.120	− 0.162
Kurtosis	1.865	2.028	2.153	4.141	2.409	1.846
Observations	43	43	43	43	43	43

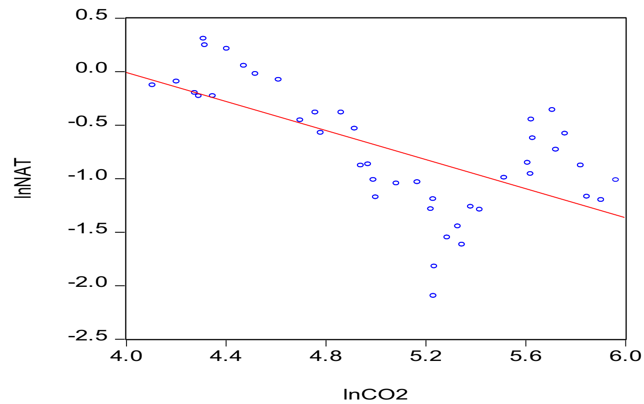


Fig. 1 Scatter aplot

After exploring the unit root levels and cointegration relations of variables, long- and short-term coefficients are estimated. Table 5 shows the long-term coefficients of potential determinants of CO_2 through the ARDL method within the framework of Eq. 2. According to the results obtained from the ARDL model, GDP and GDP^2 affect CO_2 positively and negatively, respectively. A 1% enhancement in GDP enhances CO_2 by 0.254%. A 1% enhancement in the GDP^2 reduces CO_2 by 0.015%. The findings imply an inverse U-shaped linkage between income and CO_2 in Turkey. In other words, the EKC hypothesis is valid in Turkey. The results are consistent with Halicioglu (2009), Boluk and Mert (2015),

Table 2 ADF and LS unit root tests

Variables	ADF		LS	
	Intercept	Trend and intercept	Test value	Time break
$\ln CO_2$	− 0.823	− 2.948	− 2.318	2000
lnGDP	0.880	− 1.933	− 2.572	2010
$\ln GDP^2$	1.039	− 1.751	− 2.204	2010
lnREN	− 1.647	− 2.677	− 3.050	1987
lnTRA	− 1.659	− 2.509	− 2.969	1986
lnNAT	− 1.651	− 1.794	− 3.052	1989
lnENE	− 0.840	− 2.594	− 2.636	1985
$\Delta \ln CO_2$	− 7.357***	− 7.269***	− 5.184***	2004
ΔlnGDP	− 6.292***	− 6.650***	− 4.416***	2002
$\Delta \ln GDP^2$	− 6.204***	− 6.630***	− 4.516***	2002
ΔlnREN	− 8.366***	− 8.273***	− 4.359***	1988
ΔlnTRA	− 4.792***	− 4.873***	− 4.084***	1985
ΔlnNAT	− 6.219***	− 6.160***	− 4.269***	2010
ΔlnENE	− 7.060***	− 6.696***	− 6.331***	1986
Critical values				
1% level	− 3.596	− 4.192	− 4.084	
5% level	− 2.933	− 3.520	− 3.487	
10% level	− 2.604	− 3.191	− 3.185	

***Significance at 1%

Table 3 Bound test

Optimal lag	*F*-statistic	$R^2 = 0.98$	Result
(3, 3, 0, 0, 3, 4, 4)	54.258***		Cointegrated
LM(1) = 1.034	ARCH (1) = 0.255		
Normality = 0.294	RESET = 0.271		

***Significance at 1%

and Uzar and Eyuboglu (2019a). According to the results, an increase in the level of income is enhancing CO_2 in Turkey. However, if the increase in income level continues, it indicates that the environmental effects of economic growth will decrease. CO_2 can be reduced through composition and technical effects, especially with a certain level of income achieved. As the income level increases, the size of the service sector, which has a lower environmental impact, increases. Also, the increased income level facilitates the raise of resources allocated to R&D activities that will enable the development of environmental technologies and ensure the integration of clean technology into the production process. Finally, the increasing income level increases people's environmental awareness and increases the demand for environmental quality (Danish et al. 2019). All these developments serve as an important catalyst in reducing CO_2.

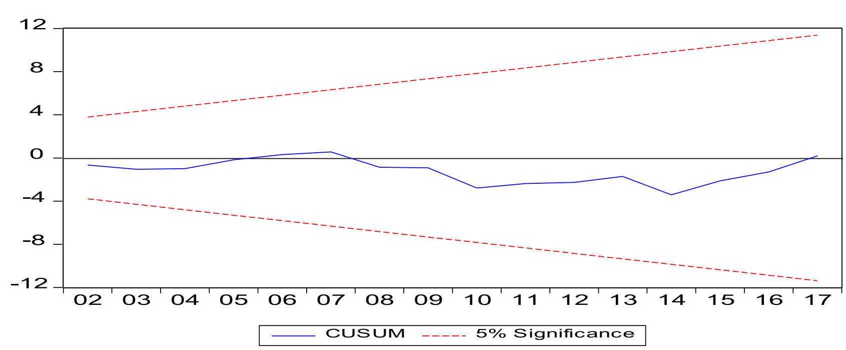
Long-term coefficient estimates indicate that the use of REN in Turkey is an important factor in reducing CO_2. In this context, a 1% increase in REN diminishes CO_2 by 0.110%. The promotion of REN in Turkey, and the reduction of CO_2, will be a very important factor in improving environmental quality. It is consistent with Boluk and Mert (2015). REN sources such as wind, solar, hydropower, and geothermal, which are described as environmentally friendly and ecological, are sustainable energy sources that can be reproduced with the use of existing resources. In this context, REN sources have less CO_2 compared with fossil fuels. Negative nexus between two variables can be explained by the significant steps made in Turkey's renewable energy capacity in recent years. BP (2020) data shows the rapid increase in the creation of renewable energy in the 2000s. Also, the Renewables Global Status Report (2019) stated that Turkey makes a major capacity expansion in the hydroelectric and solar energy field. These developments in the field of REN see an important role in reducing CO_2 in Turkey.

TRA can affect CO_2 through scale, composition, and technical effects. The positive effect indicates that the scale effect is dominant, while the negative indicates that the composition and technical effects are valid. According to our findings, while the effect of TRA on CO_2 is positive in the long term, the coefficient is not statistically significant. In this context, although the coefficient of TRA shows that the scale effect is valid, the lack of statistical significance indicates that the effect of TRA on CO_2 cannot be interpreted properly. This result is not similar to Halicioglu (2009).

The long-term coefficient of NAT, which is the main independent variable of the study, is negative and significant. In this context, a 1% increase in natural resources diminishes CO_2 by 0.015%. Thus, we can conclude that the abundance of NAT is an important determinant for the reduction of environmental pollution in Turkey. The results are consistent with Balsalobre-Lorente et al. (2018) and Danish et al. (2009) for Russia. Our results are inconsistent with Hassan et al. (2019) and Danish et al. (2019) for South Africa. These results suggest NAT could be used effectively in Turkey. In other words, the use of NAT by limiting the import of fossil fuels which is relatively high in Turkey has contributed to the reduction of CO_2. In this context, the reduction of imports of energy sources with high CO_2 such as oil and coal and the use of local sources with lower pollution rates help reduce environmental degradation. Turkey has a large number of streams, which positively affected hydroelectric production. Also, the widespread use of clean energy sources in the production of electricity decreases the dependence on foreign energy and also reduces the emission pressure created by fossil fuel use. In this context, the use of renewable local resources is an important catalyst for CO_2 reduction.

Long-term coefficients denote that ENE is the most affecting variable on CO_2 in Turkey. Findings show that ENE affects CO_2 positively and statistically significant. A 1% increase in ENE increases CO_2 by 1.046%. Although Turkey has increased the use of renewable energy in recent years, the weight of non-renewable energy is still very much in the

Fig. 2 CUSUM



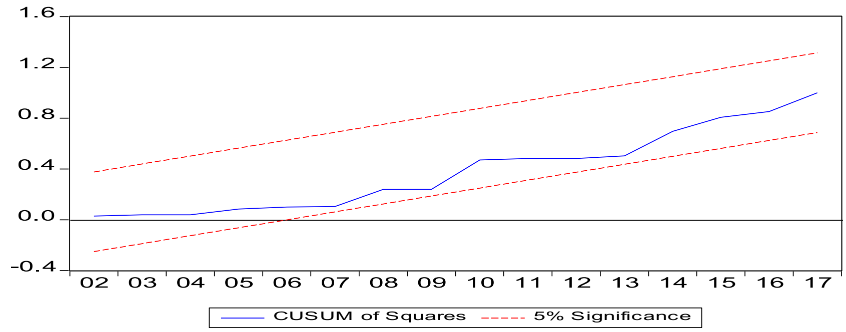


Fig. 3 CUSUM of squares

energy portfolio (Ocal and Aslan 2013; Uzar and Eyuboglu 2019b). This result shows that the production process and energy portfolio are still far from being environmentally friendly. In other words, the characteristic of economic activities in Turkey is based on a significant amount of fossil-based sources. This indicates that energy efficiency could not be achieved. Especially, when considering Turkey's increasing energy demand, the lack of energy efficiency may disrupt the CO_2 reduction targets of Turkey.

To investigate the robustness of the ARDL results, the long-term effects of independent variables on CO_2 are estimated by employing FMOLS and DOLS. Table 6 shows the results from ARDL, FMOLS, and DOLS estimators. Results are very close to each other in terms of coefficients and coefficient signs. According to the FMOLS and DOLS estimators, GDP affects CO_2 positively and statistically significant. On the other hand, the coefficient of the GDP^2 is negative and statistically significant. Thus, FMOLS and DOLS estimators are also confirmed that EKC is valid in Turkey. The coefficients of the variables of REN and NAT are statistically significant and negative. Alternative estimators also point out that REN and NAT are crucial factors in diminishing CO_2. The coefficient of ENE is positive and statistically significant. FMOLS and DOLS estimators also show that ENE is a threat to environmental quality in Turkey. Although the coefficient of TRA is positive, it is insignificant.

The short-term estimation results are reported in Table 7. The coefficient of the ECT is negative and significant, meaning that the results are consistent with the findings of the long term. Narayan and Smyth (2006) emphasized that the ECT coefficient is between − 1 and − 2, which implies that instead of monotonically converging to the equilibrium path directly, the error correction process fluctuates around the long-term value in a dampening manner. To check the joint short-term effect of lag values of variables, their joint significance is tested by using the Wald coefficient test. Short-term coefficients and their significance are similar to long-term results. GDP and ENE also positively affect CO_2 in the short term. Therefore, the dynamics of GDP and ENE are increasing CO_2 in Turkey, even in the short term. On the other hand, NAT, our main explanatory variable, also reduces CO_2. In this context, NAT is a very critical factor in reducing CO_2 both in the short and long term. Finally, the short-term coefficient of TRA is statistically insignificant, as is the long-term coefficient. Therefore, it can be said that TRA does not have a significant effect on CO_2 in the short term.

The causal relationship between CO_2, GDP, NAT, REN, TRA, and ENE is investigated by the VECM method. Findings from causality tests are presented in Table 8. Findings denote that all independent variables are the cause of CO_2 in the long term. In this context, GDP, NAT, REN, TRA, and ENE will affect CO_2 in the long term. In this context, economic activities and energy consumption can have an impact on CO_2 in Turkey. In this respect, the information obtained from the causality analysis supports the information obtained from long-term estimators. In the short term, there is no causal nexus between REN, TRA, and NAT and CO_2, while GDP and ENE are the cause of CO_2. It can be concluded that short-term dynamics in GDP and ENE have an impact on CO_2. These results show that current economic and energy policies in Turkey directly affect environmental quality both

Table 4 Bayer and Hanck

EG-JOH-BO-BDM	Critical value (%5)	Result
91.349	20.143	Cointegrated

Table 5 ARDL model coefficients

Variables	Coefficient	Std. error	*t*-statistic
lnGDP	0.254***	0.019	12.81
lnGDP2	− 0.015***	0.003	− 4.423
lnREN	− 0.110***	0.012	− 8.660
lnTRA	0.013	0.017	0.791
lnNAT	− 0.015***	0.003	− 4.438
lnENE	1.046***	0.047	22.12

***Significance at 1%

Table 6 Long-term estimates by estimators

	ARDL	FMOLS	DOLS
lnGDP	0.254***	0.274***	0.208***
$LnGDP^2$	− 0.015***	− 0.019***	− 0.273***
lnREN	− 0.110***	− 0.108***	− 0.077***
lnTRA	0.013	0.007	0.020
lnNAT	− 0.015***	− 0.013**	− 0.014**
lnENE	1.046***	1.081***	1.288***

***Significance at 1%

**Significance at 5%

in the short and long term. Thus, to reduce its dependence on traditional energy policy, ensuring energy efficiency and the use of local renewable energy sources will help to diminish CO_2 and environmental pressure in Turkey.

To summarize, the impact of independent variables on CO_2 in the long term is similar for all applied estimators. The findings showed that the EKC is valid in Turkey. In addition, NAT and REN reduce CO_2 in the long term, while GDP and ENE increase. TRA is not effective in the long term. Short-term estimates have the same sign and significance level as long-term estimates. Therefore, the independent variables have an impact on CO_2 in the short term as well as in the long term. Causality results indicated that all independent variables are the cause of CO_2 in the long-term. Therefore, causality findings support long-term coefficients.

Table 7 ECM

Variables	Coefficient	Standard error	*t*-statistic	*p* value
$\Delta lnCO_2(-1)$	0.353	0.048	7.219	0.000
$\Delta lnCO_2(-2)$	0.138	0.042	3.288	0.004
ΔlnGDP	0.463	0.046	9.992	0.000
ΔlnGDP(−1)	− 0.092	0.040	− 2.286	0.036
ΔlnGDP(−2)	− 0.158	0.048	− 3.237	0.005
ΔlnTRA	0.005	0.011	0.461	0.650
ΔlnTRA(−1)	− 0.005	0.011	− 0.454	0.634
ΔlnTRA(−2)	− 0.052	0.014	− 3.586	0.002
ΔlnNAT	− 0.025	0.006	− 3.990	0.001
ΔlnNAT(−1)	− 0.050	0.007	− 6.730	0.000
ΔlnNAT(−2)	− 0.013	0.005	− 2.428	0.027
ΔlnNAT(−3)	− 0.027	0.004	− 5.627	0.000
ΔlnENE	1.236	0.045	27.17	0.000
ΔlnENE(−1)	− 0.304	0.053	− 5.664	0.000
ΔlnENE(−2)	− 0.085	0.048	− 1.777	0.094
ΔlnENE(−3)	− 0.166	0.027	− 6.039	0.000
ECT(−1)	− 1.665	0.072	− 22.85	0.000

Conclusion and policy implications

Researchers and policymakers have been making efforts to identify the causes of environmental degradation. The increasing numbers of studies that attempt to identify the determinants of CO_2 indicate the continued interest on the subject. Although many variables have been used to explain CO_2 in the relevant literature, NAT have been neglected by researchers. Given that the NAT have potential impacts on environmental quality, detailed analysis of their interaction with CO_2 is important. Thus, the impact of NAT on CO_2 in the framework of EKC methodology for the 1975–2017 period in Turkey is determined. GDP, REN, TRA, and ENE are included to prevent the omitted variable bias.

The ARDL model estimations reveal that the EKC is valid in Turkey. Thus, environmentally friendly technologies, strict environmental policies, environmental awareness, and sectorial change at a high-income level will reduce CO_2 emission. The findings show that NAT, which are the main independent variable, can be an important factor in reducing CO_2. In other words, the use of NAT in Turkey contributes to the reduction of CO_2 emission by reducing fossil fuel imports. These results demonstrate that the use of NAT may be an important factor in reducing environmental problems in Turkey. We also discover that REN may be an important factor in the reduction of CO_2. ENE is a critical factor that increases CO_2. This result indicates that ENE is not environmentally friendly, and energy efficiency cannot be achieved within this framework in Turkey. The effect of TRA on CO_2 is statistically insignificant. In the study, FMOLS and DOLS estimates are applied to test the robustness of the results. The results obtained from these estimators are consistent with the findings of the ARDL. Finally, the causality results show that all independent variables cause CO_2 in the long term.

Results have important policy implications for Turkey. In this context, the negative nexus between NAT and CO_2 is an important strategy to ensure the energy efficiency for policymakers and to effectively use NAT to reduce CO_2. Although Turkey has made significant investments in renewable energy capacity, the use of renewable energy potential is still limited. Therefore, additional efforts should be exerted to discover renewable NAT in the country. The discovery of new resources primarily depends on the use of finance and technology. Therefore, more resources should be transferred to research and development activities, whereas the private sector should be supported with incentives. This condition will ease the shift of energy composition to REN in Turkey. The extraction and excessive use of NAT may adversely affect the environment over time. In this framework, the methods of extraction of NAT and their efficiency should be strictly controlled. The energy-efficient equipment used by firms, which extract NAT and cause damage to nature, should be carefully checked.

Table 8 VECM results

Dependent variable	Short-term						Long-term ECT_{t-1}
	$\Delta lnCO_2$	ΔlnGDP	ΔlnREN	ΔlnTRA	ΔlnNAT	ΔlnENE	
$\Delta lnCO_2$	-	0.140**	0.102	0.230	− 0.661	0.060**	− 0.747***

***Significance at 1%

**Significance at 5%

Although this study contributes to the literature, it has several limitations. The first limitation of this study is that it only uses CO_2 as an environmental indicator. Therefore, future studies can examine the environmental impacts of NAT using different environmental indicators, such as ecological footprint, biodiversity, and water pollution. Thus, the effect of NAT on the environment can be revealed more comprehensively. Another limitation of the study was methodology. This study estimated the long-term impact of NAT on CO_2 through ARDL, FMOLS, and DOLS estimators. Although these methods are functional, they are traditional. Therefore, future studies can examine the relationship between NAT and CO_2 using up-to-date econometric techniques such as dynamic ARDL (Sarkodie et al. 2019).

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