Environmental implication of coal and oil energy utilization in Turkey: is the EKC hypothesis related to energy?

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Abstract

Purpose – In spite of the drive toward environmental sustainability and the attainment of sustainable development goals (SDGs), coal, oil and natural gas energy utilization has remained the Turkey's largest energy mix. In view of this concern, this study examined the role of coal and oil energy utilization in environmental sustainability drive of Turkey from the framework of sustainable development vis-à-vis income expansion over an extended period of 1965–2017.

Design/methodology/approach – In this regard, the authors employ carbon emission as an environmental and dependent variable while the Gross Domestic Product per capita (GDPC), coal and oil energy consumption are the explanatory variables employed in the study.

Findings – The study found that both energy mixes (coal and oil) have a detrimental impact on the environment in both the short and long run, but oil consumption exerts a less severe impact as compared to coal energy. In addition, sustainable development via income growth is not feasible because the income–environmental degradation relationship follows a *U*-shaped pattern (invalidating the Environmental Kuznets curve, EKC hypothesis) especially when coal and oil remained the major source of lubrication to the economy. At least the EKC hypothesis is unattainable in Turkey as long as the country's major energy mix or primary energy (coal and oil) is in use, thus the application of other socioeconomic, macroeconomic policies might be essential.

Research limitations/implications – Considering the lingering energy challenge associated with Turkey, this novel insight further presented useful policy perspectives to the government and stakeholders in the country's energy sector.

Originality/value – This evidence (the *U*-shaped relationship) is further ascertained when the aggregate primary energy is employed. Thus, this study provides a novel insight that attaining a sustainable economic growth in Turkey remained a herculean task as long as a more aggressive energy transition approach is not encouraged.

Keywords Environmental quality, Carbon emissions, Coal and oil utilization, EKC, Turkey

Paper type Research paper

1. Introduction

The current phase of industrial revolution and a drive to attain a more competitive economy globally as further paved way for the rise in environmental degradation, this is not withstanding the socioeconomic, demographic, natural and other factors (Ozturk, 2010; Ahmed *et al.*, 2019; Alola, 2019 a, b). It is due to this, that since the 1980s, scientists have been fascinated by scrutinizing the trade-off that exists between sustainable economic productivity and environmental issues. Investigations on sustainable economic productivity and issues concerning the environment in the centuries have been a center of concern for many nations worldwide by making use of different approaches and range of data period to analyze the connection between the mentioned variables (Oh and Lee, 2004;

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Acheampong, 2018; Kasman and Duman, 2015; Pao and Tsai, 2010; Wang *et al.*, 2018). Environmental pollution (mostly caused by increasing greenhouse gas emissions from economic activities) has remained a threat to global economies, thus causing various governments to invest a huge amount to mitigate the hazards (Ali *et al.*, 2019). This is because developing and developed nations are progressively being confronted with the double task of stimulating economic productivity and addressing environmental issues (Munir *et al.*, 2020).

In formulating environmental programs, the main goal of policymakers varies across the economies of the world. It is idealistic to expect all developing countries to have the same objective, which is the main goal of attaining increased output possibly at the expense of environmental quality. Thus, policymakers' sustainable approach to improve environmental quality is by defining sustainable environmental strategies (Ibrahim and Law, 2015). Theoretical studies have measured this trade-off between sustainable economic growth and environmental degradation. Likewise, rising numbers of empirical investigations have scrutinized the determinants of environmental degradation and its causal relationship with economic growth. For instance, Kuznets (1955) initially suggested the theory of economic growth and environmental degradation where an inverted *U*-shaped is subsequently established. Additionally, Grossman and Krueger (1993) specified in a related study to scrutinize this trade-off between sustainable economic productivity and environmental destruction, several theoretical and empirical studies followed in establishing this link (Shahbaz and Sinha, 2019; Altıntaş and Kassouri, 2020; Dogan and Inglesi-Lotz, 2020).

Several studies have put forward the studies on the trade-off between economic growth and environmental degradation: such as the European Union (Bekun *et al.*, 2019), Qatar (Salahuddin and Gow, 2019), Turkey (Ozcan *et al.*, 2018), 34 Asian countries (Le *et al.*, 2019), 63 countries (Ahmed *et al.*, 2019), Brazil (Zambrano-Monserrate *et al.*, 2016), just to name a few. Different approaches used by scientists have attempted to scrutinize this trade-off from the context of different energy forms, non-energy-related factors, socioeconomic and other factors. In addition, numerous pollutants such as the carbon dioxide (CO_2) emissions, nitrogen oxide (NOx), sulfur dioxide (SO_2) and suspended particulate matter have consistently been explored as proxy for environmental degradation. Moreover, energy consumption, especially the nonrenewable energy sources have proven to be a significant source of environmental hazard. For instance, Bekun *et al.* (2019) mentioned that energy emission is a significant leading pollutant causing environmental hazards that arise as a result of economic growth.

According to the Climate Change Performance Index-CCPI (2016), Turkey has a very poor performance in terms of environmental protection with her position as the 50th out of 61 nations around the world. This undesirable environmental performance of Turkey is largely due to the lack of sufficient sustainable program that is aimed at limiting the level of emissions in the country. Besides, the economy of Turkey is fast growing, which is largely attributed to many factors that have consistently stimulated the productivity rate and that then causing various forms of pollutant emission (Gökmenoğlu and Taspinar, 2016; Ozturk and Acaravci, 2013; Chandio *et al.*, 2020). The information from the Turkey's energy mix is a familiar reflection to draw inference for the country's environmental performance. For instance, the International Energy Agency, IEA (2019) observed that the energy mix for Turkey largely remained coal, oil and natural gas. In specific, the 2018 energy consumption by source in Turkey was recorded as 43, 265.0 kilo tonnes, 42, 003 kilo tonnes, 41, 096.0 kilo tonnes, 11, 399.0 kilo tonnes, 5, 138.0 kilo tonnes and 3040.0 kilo tonnes for coal, oil, natural gas, wind–solar–other-related energy sources, hydro and biofuel-waste, respectively (International Energy Agency, 2019).

Given the aforementioned motivation, it is essential to further scrutinize the relationship between sustainable economic growth, energy consumption and environmental degradation vis-à-vis CO_2 emissions for the case of Turkey. Although a few studies have examined related scenario, for certain reasons, the current study has the potential of providing a significant contribution to extant studies. For instance, the current study employed the main two of the three energy sources in Turkey, which are coal and oil with the exemption of natural gas due to insufficient data availability. As such, the role of coal and oil consumption in environmental performance in Turkey is hypothesized. In addition, the income–environmental degradation relationship is again put into perspective from the framework of the EKC hypothesis. In achieving this, the current study hypothesized if the possibility of EKC hypothesis in Turkey is related with the energy mix of the country. As such, the aggregate primary energy consumption is employed to further provide a novel insight that rather opined that the *U*-shaped hypothesis is largely feasible for the case of Turkey especially when energy consumption is mainly considered. Thus, by exploring the aforementioned pathways, the current study is expected to significantly contribute to the existing literature as well providing corrective measures to help policymakers establish a more effective future liaison between sustainable economic productivity and environmental hazards.

The remainder of this interesting study is organized as follows. Section 2 dwells briefly on the literature perspectives; Section 3 is on data and methodology; while Section 4 is on empirical results interpretation; finally, conclusion and policy recommendations are rendered in Section 5.

2. Sustainable development – energy pollutant emissions

Turkey has experienced great improvement in the economic growth in recent time (Uzar and Eyuboglu, 2019). This steady increase in growth rate, without doubt, resulted in extra consumption of energy, in the beginning of the 1990s (Ozturk and Acaravci, 2010). Ozturk and Acaravci (2010) opined that high energy consumption is responsible for the rise in CO_2 emissions. Similar to their previous study, Ozturk and Acaravci (2013) found a cointegration between per capita energy consumption, per capita income, financial development and carbon emissions for the period of 1960–2007. In addition, Kaygusuz (2009) noted that the increase in electricity consumption amidst consistent years of economic growth has been widely associated with the unabated environmental hazard in Turkey.

Furthermore, Saint Akadiri *et al.* (2019) examined the determinants of environmental sustainability in the context of real income, tourism and globalization. By employing the Bayer–Hanck combined cointegration and the autoregressive distributed lag (ARDL) approaches for the period of 1970–2014, the study posited that real income is a significant determinant of environmental sustainability in the country. In specific, it offered that the growth of real income is detrimental to environmental quality because it triggers the increase of per capita CO_2 emissions (measured in metric tonnes) in both the short and long run. In the case of other economies, Wang *et al.* (2020) examined the link between economic factors and CO_2 emissions across the Eastern, Central and Western provinces of China. The study found a unidirectional causality from income per capita to CO_2 emissions only in the Eastern and Central provinces of the country. Moreover, Rathnayaka *et al.* (2018) employed data for the period of 1980–2013 and explored the underlying correlation between sustainable economic growth and environmental concerns in China. The results from this study affirmed a significant bidirectional causal relationship between economic development and environmental degradation in the long run.

Importantly, several studies have illustrated similar observations relative to the Turkish experience (Al Mulali *et al.*, 2014; Ben Jebli *et al.*, 2014; Alola *et al.*, 2019a, b; Bekun *et al.*, 2019; Danish *et al.*, 2020). In specific, Direkci and Govdeli (2016) argued in support of the causality nexus between economic growth and environmental pollutants, thus affirming the four hypotheses: (1) Feedback hypothesis states that increase in consumption of energy will generate a positive effect on economic productivity, and an increase in economic productivity will increase energy consumption, meaning that the nexus between both variables is bidirectional (Al Mulali *et al.*, 2014; Ben Jebli *et al.*, 2014). (2) The neutrality hypothesis assumes that the share of consumption of energy within the aggregate output is very small, and a change in energy consumption does not impact on the growth rate of the real GDP (Odhiambo, 2009; Abosedra *et al.*, 2015). (3) Conservation hypothesis states that unidirectional liaison runs from productivity to emission of energy, and an increase in productivity causes an increase in energy emission (Apergis and Payne, 2009), (Esso, 2010). (4) The Growth hypothesis assumes that the causality from the consumption of energy to GDP is unidirectional, and restrictive policies on energy consumption will adversely affect economic growth (Belke *et al.*, 2011; Ozturk, 2010).

Moreover, specific energy mix components expectedly provide different environmental dimensions. In the literature, the environmental perspectives of alternative and conventional energy and especially energy sources from coal, fossil fuel, natural gas, solar, thermal, biofuels, nuclear and so on have been explicitly detailed (Alola *et al.*, 2019a; Destek and Sarkodie, 2019; Farhani and Balsalobre-Lorente, 2020; Asongu *et al.*, 2020; Joshua and Alola, 2020; Umar *et al.*, 2020; Usman *et al.*, 2020; Onifade *et al.*, 2021; Saint Akadırı *et al.*, 2021). For instance, Farhani and Balsalobre-Lorente (2020) employed a set of cointegration techniques to examine the emission effects of gas, oil and coal in the world's three largest economies (China, the USA and India) over the period of 1965–2017. While the study validates the EKC hypothesis for the USA and India, the EKC hypothesis is however not valid for China without the inclusion of gas consumption in the model. Similarly, the recent study of Saint Akadırı *et al.* (2021) examined the validity of EKC hypothesis from the perspective of economic freedom for the Brazil, Russia, India, China and South Africa (BRICS) economies over an experimental time of 1995–2018. In addition, the mix of coal, natural gas and oil energy utilization poses a serious danger to the bloc's environmental quality. However, Akadırı *et al.* (2021) demonstrate that natural gas has the potential of mitigating carbon emission in South Africa. Meanwhile, Joshua and Alola (2020) attested to the environmental problem associated with the coal-leg growth situation of South Africa.

2.1 Turkey: the EKC hypothesis

Kuznets (1955) suggested that the hypothesis on the theoretical nexus of economic growth and environmental degradation followed an inverted *U*-shape pattern, the EKC hypothesis. This inverted *U*-shape curve is also because industrial activity, in the long run, will be shifted to developing nations to reduce pollution (Cherniwchan, 2012; Fæhn and Bruvoll, 2009). Besides, McConnell (1997) came out with empirical results that validate the EKC hypothesis. However, other scholars such as Stern (2004) and later Adedoyin *et al.* (2019) for the case of BRICS are few of the several studies that have scrutinized the possible link between carbon emissions and increased productivity for various countries. Moreover, Gökmenoğlu and Taspinar (2016) and several other studies have specifically examined the validity of the EKC hypothesis for the case of Turkey. In specific, a summarized presentation of the studies of EKC hypothesis for the case of Turkey and with differing results is illustrated in Table 1.

Given the differing result of the EKC hypothesis for the case of Turkey as illustrated in Table 1, the justification for this project is to fill the existing gap in the literature by illustrating the relevance of energy mix in the EKC hypothesis theory in Turkey.

3. Data and method

3.1 Data

This study uses the carbon emission (henceforth regarded as CEM) that is measured in million tonnes of CO_2, the coal consumption (henceforth regarded as COALC) that is

Table 1. A review of EKC hypothesis study for Turkey

Author	Experimental period	Key variables	EKC result
Bulut (2020)	1970–2016	GDP, ecological footprint, foreign direct investments, renewable energy consumption and industrialization	EKC is valid
Pata (2018)	1969 to 2017	CO_2, trade openness and GDP per capita	EKC is valid
Akbostancı *et al.* (2009)	1968–2003	PM_{10}, SO_2 and GDP per capita (income)	EKC is not valid
Bölük and Mert (2015)	1961–2010	CO_2, electricity generated using renewables and GDP	EKC is valid
Katircioğlu and Katircioğlu (2018)	1960–2013	CO_2, fuel oil, energy consumption and urban development	EKC is not valid
Katircioğlu and Taşpinar (2017)	1960–2010	Financial development, real GDP, CO_2 and energy use	EKC is not valid
Tutulmaz (2015)	1968–2007	CO_2 and GDP per capita	EKC is not valid
Gozgor and Can (2016)	1971–2010	Economic growth, energy consumption, export product diversification and CO_2	EKC is valid
Pata (2018)	1971–2014	CO_2 emissions, economic growth, financial development, trade openness, industrialization, urbanization, coal and noncarbohydrate energy consumption	EKC is valid
Aydin and Esen (2017)	1971–2014	CO_2, GDP per capita, environmental pollution and income level	EKC is not valid
Ozcan *et al.* (2018)	1961–2013	Ecological footprint and economic growth	EKC is not valid
Elgin and Öztunalı (2014)	1950–2009	Informal sector (as percentage of official GDP), carbon dioxide and sulfur dioxide emissions	EKC is valid
Özokcu and Özdemir (2017)	1980–2010	Economic growth, income and CO_2	EKC is not valid
Yavuz (2014)	1960–2007	Per capita CO_2 emission, per capita income and per capita energy consumption	EKC is valid
Tunçsiper and Uçar (2017)	1980–2011	CO_2 and per capita income	EKC is not valid
Kaya and Kaya (2017)	1975–2012	CO2 emissions per capita, gross domestic product per capita, energy consumption and financial development	EKC is not valid
Dogan (2016)	1968–2010	Agricultural performance and the carbon dioxide emission	EKC is valid
Yurttagüler and Kutlu (2017)	1960–2011	Income, CO_2, environmental quality and economic growth	EKC is not valid
Bilgili *et al.* (2016)	1977–2010	Renewable energy consumption, environmental quality (in terms of CO_2 emissions) and GDP per capita	EKC is valid
Ozturk and Acaravci (2010)	1968–2005	Economic growth, carbon emissions, energy consumption and employment ratio	EKC is not valid
Acar and Aşıcı (2017)	1961–2008	Ecological footprint and income	EKC is valid
Balıbey (2015)	1974–2011	Economic growth, carbon dioxide emission and foreign direct investment (FDI)	EKC is valid
Seker *et al.* (2015)	1974–2010	Foreign direct investment (FDI), together with gross domestic product (GDP), the square of GDP and energy consumption, on carbon dioxide (CO_2)	EKC is valid
Koçak and Şarkgüneşi (2018)	1974–2013	Foreign direct investments and CO_2	EKC is valid
Güçlü (2016)	2008–2013	Sulfur dioxide ($S0_2$) and GDP	EKC is not valid

Note(s): RUR: Ruralization, GDPC: Gross Domestic Product Per Capita, POP: Population, REN: Renewable Energy, NRT: Natural Resource Rent, ELE: Electricity Energy Consumption, NEC: Nonrenewable Energy Consumption, EI: Energy Intensity, CT: Cargo Turnover, SER: Service Share, PC: Private Vehicle Population, EF: Ecological Footprint, FDV: Financial Development, ECO: Energy Consumption, EXP: Export, IND: Industrialization, TECH: Technology, TRANSP: Transportation, GDP: Gross Domestic Product measured in million tonnes and the oil consumption (henceforth regarded as OILC) that is also measured in million tonnes. The aforementioned variables were retrieved from the British Petroleum (BP). In order to accomplish the priority of the study, the Gross Domestic Product per capita from the World Bank Development indicator that is measured as constant United States dollars (USDs) for 2010 was also used. All the employed variables were transformed to natural logarithmic and additional variable-specific information and evidence of respective correlation are illustrated in Table A1 in Appendix.

3.2 Method

In addition to the descriptive statistics of the series that illustrates the statistical properties of each variable (such as the evidence of normal distribution (except for GDPC) and the relative deviation from respective mean), the time series plot and the stationarity evidence of the series are illustrated as *a priori* inference (see Figure 1 and Table 2). The ADF (augmented Dickey–Fuller) of MacKinnon (1996) and the stationarity test of Kwiatkowski *et al.* (1992) vis-à-vis KPSS were employed to examine the series' stationarity. Indicatively, all the series were found to be stationary after the first difference, that is, I (1) (see Table 2) to pave way for the estimation procedures.

Considering that extant studies have linked environmental effect of income to other factors, the current stud explores this dimension in the context of coal and oil consumption with this model:

$$CEM_t = f\left(GDPC_t, GDPCsq_t, COALC_t, OILC_t\right) \tag{1}$$

3.2.1 Cointegration and other techniques. Considering the visual evidence of comovement from the time series plot of Figure 1, a cointegration is performed. The employed cointegration test implied that there is evidence of cointegration (see the lower part of Table A1). Thus, the bound test to cointegration approach of ARDL of Pesaran *et al.* (2001) is employed to determine the contributions of the GDPC, GDPsq, COALC and IOLC to carbon emissions in Turkey. The ARDL is considered suitable, largely because of its effectiveness for small sample size observation and that it clearly presents the impacts in both the short and long run. As such, the model (1) can be further expressed in a functional form as

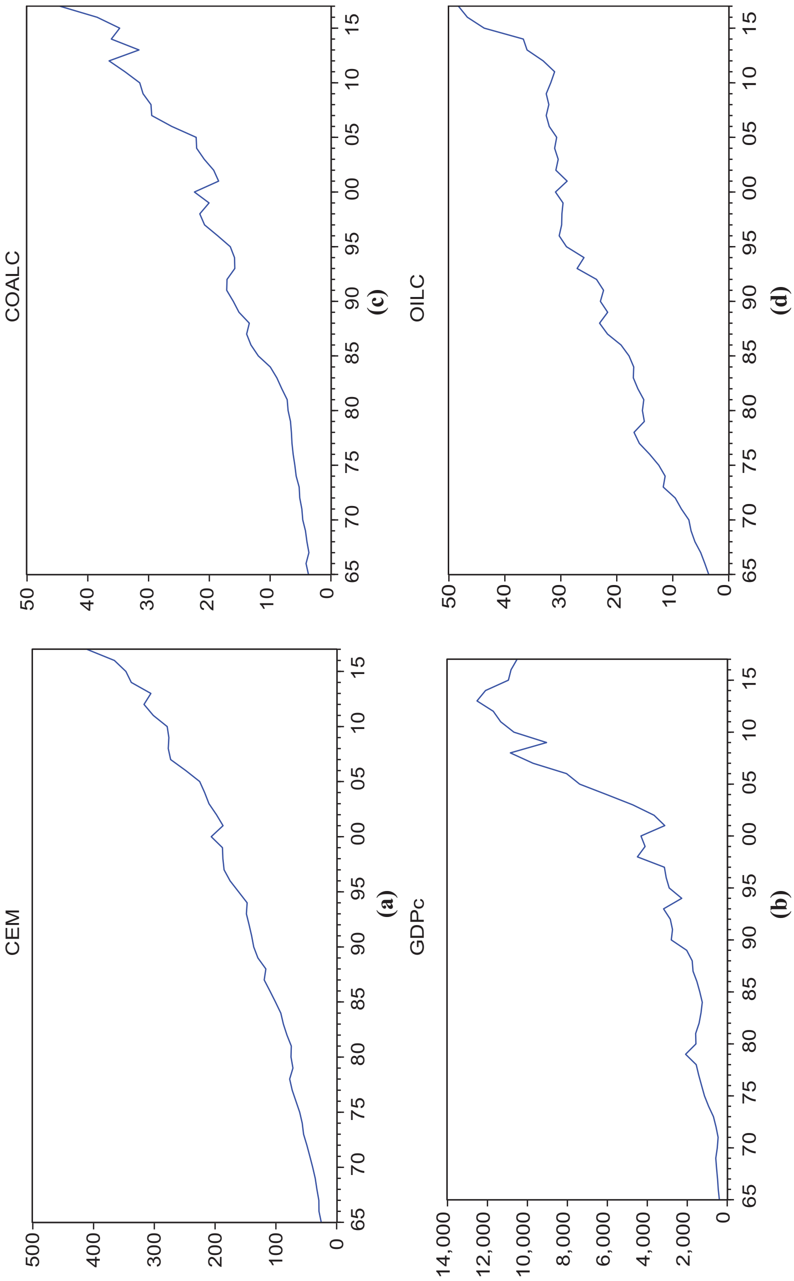
$$CEM_t = \pi_0 + \pi_1 GDPC + \pi_2 GDPCsq + \pi_3 COALC + \pi_4 OILC + \varepsilon_t \tag{2}$$

where $t = 1965, 1966, 1967, \ldots, 2017$ and the error term is the ε_t. The π_0 is the intercept while the $\pi_1, \pi_2, \pi_3,$ and π_4 are the respective impact of the respective variables.

In order to examine the long and short run from Equation (2), the ARDL-bound test approach is employed such that

$$\begin{aligned} CEM_t = {} & \pi_0 + \pi_1 CEM_{t-1} + \pi_2 GDPC_{t-1} + \pi_3 GDPCsq_{t-1} + \pi_4 COALC_{t-1} + \pi_5 OILC_{t-1} \\ & + \sum_{i=0}^{p^1} \lambda_1 \Delta CEM_{t-1} + \sum_{i=0}^{q^2} \lambda_2 \Delta GDPC_{t-1} + \sum_{i=0}^{q^3} \lambda_3 \Delta GDPsq_{t-1} + \sum_{i=0}^{q^4} \lambda_4 \Delta COALC_{t-1} \\ & + \sum_{i=0}^{q^5} \lambda_5 \Delta OILC_{t-1} + \theta ECM_{t-1} + \varepsilon_t \end{aligned} \tag{3}$$

where the lag of the residual and difference operator is respectively ECM_{t-1} and Δ. In brevity, the first and second parts of Equation (3) are employed respectively to obtain long- and short-



Note(s): The Gross Domestic Product per capita, coal consumption, and oil (energy consumption over the period 1965-2017 are respectively denoted by GDPC, COALC, and OILC

Figure 1.
The time series plot of the estimated variables

Table 2.
Descriptive statistics and unit root test with ADF and KPSS

Variable	Mean	Median	Maximum	Minimum	Skewness	Kurtosis	Jarque–Bera	Number of observation
CEM	4.547	4.636	5.839	2.583	−0.619	2.686	3.674	53
GDPC	19.193	19.348	22.511	15.681	−0.264	2.672	0.869*	53
COALC	1231.963	1220.500	1480.000	1016.000	0.422	2.873	1.641	53
OILC	4536.185	4570.500	5029.000	3778.000	−0.719	3.254	4.756	53
PRYENERGY	3.765	3.886	5.061	2.054	−0.360	2.082	3.005	53

	Level		Δ		
Unit root tests	With intercept	Intercept and trend	With intercept	Intercept and trend	Conclusion
ADF					
CEM	3.318	0.820	5.908*	7.265*	Mixed
GDPC	0.138	1.669	6.790*	6.841*	I (1)
COALC	1.690	1.137	7.759*	8.451*	I (1)
OILC	0.638	1.282	6.788*	6.831*	I (1)
PRYENERGY	−2.556	−2.967	−7.261	−7.667	I (1)
KPSS					
CEM	0.970*	0.245*	0.719	0.120	I (1)
GDPC	0.830*	0.213*	0.185	0.073	I (1)
COALC	0.960*	0.202*	0.468	0.061	I (1)
OILC	0.995*	0.078*	0.142	0.107	I (1)
PRYENERGY	0.985*	0.216*	0.471*	0.099	I (1)

Note(s): The ln, Level and Δ respectively indicate estimates of the natural logarithmic, level and the first difference. The SIC lag selection is employed for the ADF (Augmented Dickey–Fuller) and KPSS (using the Bartlett Kernel of Andrews automatic Bandwidth) unit root tests. * signifies the 1% statistical significance levels. The variables are transformed to natural logarithmic form over the period 1965–2017 run coefficients. Indicatively, $\pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = 0$ and $\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq \pi_5 = 0$ respectively illustrate the null hypothesis and alternate hypothesis of the test.

3.2.2 Robustness and diagnostic tests. In the context of the current study, the two energy variables (COALC and OILC) in the original model are replaced in the original model (1) with the primary energy consumption such that

$$CEM_t = \pi_0 + \pi_1 GDPC + \pi_2 GDPCsq + \pi_3 PENERGY + \varepsilon_t \tag{4}$$

is presented as a robustness test for the previously estimated model (Equation 1).

As such, the ARDL estimation techniques illustrated in Equation (3) are repeated for the functional form (Equation 4).

Additionally, series of diagnostic tests that include the serial correlation, heteroskedastic and normality tests are reported in Table 3, This is in addition to the results of the two aforementioned ARDL estimations and the stability test in Figure 2.

4. Results and discussion

Given the result of the short- and long-run ARDL estimation in Table 3, both oil consumption and coal consumption in Turkey are agents of environmental degradation. This is because the impact of coal and oil consumption is significant and positive in the two-stage periods, that is, short and long run. In specific, a 1% increase in coal and oil consumption is found to cause a respective increase of ~0.44 and ~0.39% in the short run and a respective increase of ~0.40 and ~0.82% in the long run. Interestingly, the impact of coal consumption was more consistent in both terms (short and long run) compared with that of oil consumption that

	GDPC	GDPCsq	COALC	OILC	ECT (−1)	Bound test
Long-run	−0.492**	0.033*	0.435*	0.392*		F-statistics = 4.797, k = 4
Short-run	−1.663**	0.104*	0.401*	0.820*	−0.296**	1%: I0 = 3.74, I 1 = 5.06

Diagnostics

Wald test: F-statistic = 48.851*, χ^2 = 195.406*	Breusch–Godfrey SR LM test: p-value = 0.316	Breusch–Pagan–Godfrey H test: p-value = 0.578
Normality (Jarque–Bera) = 3.338 (0.186)	Skewness = −0.567	Kurtosis = 3.617

Robustness illustration

	GDPC	GDPCsq	PRYENERGY	ECT (−1)	Bound test	Wald test
Long-run	−0.081	0.003	0.952*		F-statistics = 3.962, k = 2	F-statistics = 35.944*
Short-run	−0.065	0.003	0.764*	−0.803*	10%: I0 = 2.72, I 1 = 3.77	χ^2 = 143.778*
					Breusch–Godfrey SR LM test: p-value = 0.523	
					Breusch–Pagan–Godfrey H test: p-value = 0.632	

Note(s): The *p-value*, ECT, I0 and I1 are respectively the probability value, the Error Correction Term, lower and upper bound of the bound Also, χ^2 is the Chi-square, SR LM is Serial correlation Lagrange Multiplier and H is heteroskedasticity. The Gross Domestic Product per capita, the square of the Gross Domestic per capita, coal consumption and oil (energy consumption and primary energy consumption over the period 1965–2017 are respectively denoted by GDPC, GDPCsq, COALC, OILC and PRYENERGY)
*is the 1% statistical significant level; **is the 5% statistical significant level

Table 3.
ARDL-bound test

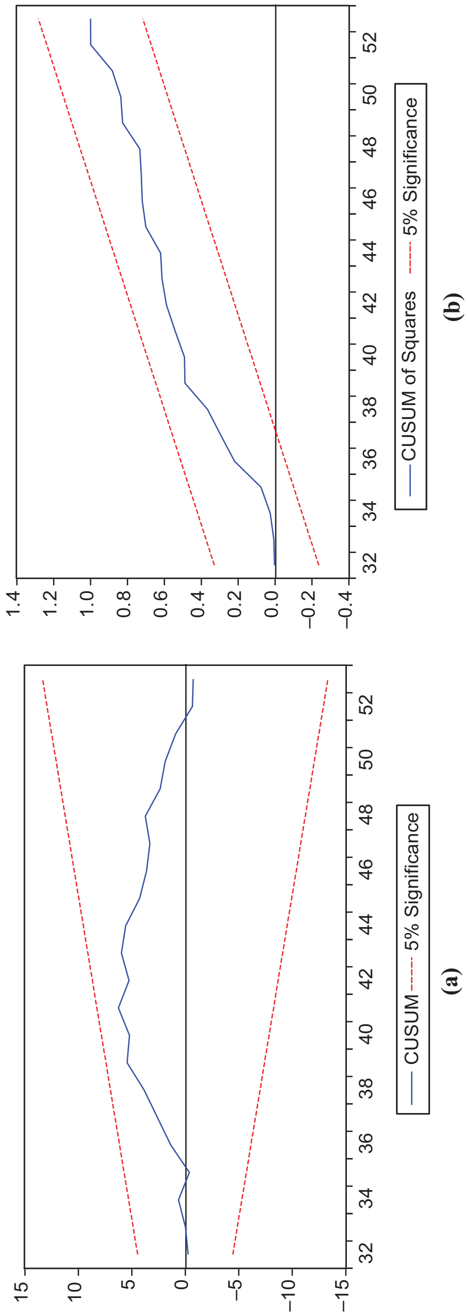


Figure 2.
The stability test of the estimation model

caused more environmental damage in the short run. The implication is that oil and coal sources of energy, which constitute the two of the Turkey's main energy mix (Hepbasli, 2004; Bilgen, 2016), are detrimental to the quality of environment in the country. In support of this result, Pata (2018) opined that coal consumption in Turkey is a significant source of environmental pollution in Turkey.

More importantly, the impact on income, that is, GDP per capita on environmental quality is observably unpleasant. The striking inference from the study is that the EKC hypothesis in invalid in the current context, rather the relationship between income and environmental degradation vis-à-vis CO_2 emissions follows a *U*-shaped pattern. In specific, a 1% increase in income (GDPC) and the square of income (GDPCsq) are responsible for 0.49% decrease and 0.03% increase in carbon emissions in the short run. Similarly, in the long run a 1% increase in GDPC and GDPCsq triggers a decline of 1.66% and increase of 0.10% in carbon emissions. This evidence demonstrates that the betterment of economic well-being or improved standard of living as seen in income growth amidst the use of coal and oil energy sources is not a sustainable growth mechanism for the country.

Considering the mixed evidence of EKC hypothesis for the case of Turkey as illustrated in Table 1, it is most certain that the possibility of an EKC hypothesis would be conditional on non-energy-related but rather economic, social and/or demographic factors such as financial development, trade activities, population and informal economic factors, among others. This assumption is supported by the result from the second model (Equation 4) that incorporated the aggregate primary energy consumption (PRYENERGY) in addition to income and square of income. From the result (see the lower part of Table 3), the relationship between income and environmental degradation follows a *U*-shaped pattern (i.e. invalidate the EKC hypothesis) especially when primary energy consumption aggregate is employed. More interestingly, the impact of primary energy consumption on environmental degradation is not desirable in both the short and long run. With an increase in the consumption of primary energy by 1%, carbon emissions worsen the environment with an incremental percentage of 0.95 and 0.76 in the long and short run respectively. This further shows that the effect of PRYENERGY on environmental quality is more detrimental in the longer term. Thus, this further shows that the energy mix in Turkey is mainly of conventional and nonrenewable energy sources.

Moreover, the aforementioned estimations are considered satisfactory based on the series of desirable diagnostic tests. In the two estimated models, there is no known drawback resulting from serial correlation, heteroskedasticity and lack of normal distribution of the series. In addition, the bound test and Wald tests further revealed and supported the evidence of long and short run in both estimations. Lastly, the stability of the estimated model is significantly ascertained by the illustration in Figure 2.

5. Conclusion remark and policy

In Turkey, natural gas, coal and oil energy are mostly utilized for the country's economic activities. Therefore, it is important to demonstrate the impact of the country energy mix or to understand Turkey's pathway to environmental sustainability amidst it economic targets. Considering the spate of environmental degradation, this study employed the ARDL approach to examine the perspective of the country's environmental quality for the period of 1965–2017. In achieving the objective of the study, the study primarily examined the role of coal and oil energy consumption in determining the country's profile of environmental degradation. In addition, the environmental quality perspective was examined within the framework of the EKC hypothesis. Thus, the study revealed that both coal consumption and oil energy consumption in Turkey have further compounded the environmental degradation challenges. Moreover, the study revealed that th e EKC hypothesis in Turkey is not valid in the current context. Interestingly, the lack of evidence of the EKC hypothesis persists even when the aggregate primary energy consumption is employed in the estimation model *in lieu* of coal and oil energy consumption. Thus, this suggests that the possibility of experiencing the EKC hypothesis in Turkey is unlikely to be energy-related. Although previous studies have affirmed the EKC hypothesis for Turkey, the current study would rather posit that the possibility of the inverted *U*-shaped (EKC) hypothesis in the relationship between income and environmental degradation could be largely dependent on other socioeconomic factors.

5.1 Policy matters

Therefore, the policy take home from the current study is expected to provide a useful information that is valuable for review of existing energy and sustainable development prospects. Considering that the Turkey's energy mix is currently not offering an impressive environmental sustainability drive, other approaches to a sustainable environment in addition should be explored. Thus, environmental-related social, cultural, attitudinal and other non-energy-related aspects of environmental sustainability practices should be encouraged in order to overturn the country's undesirable environmental sustainability outlook. However, the aforementioned policy approach should not by any means relegate the adoption of a more determined drive for energy transition and investment in cleaner energy in order to achieve a significantly higher share of renewable/cleaner energy mix.

References

Abosedra, S., Shahbaz, M. and Sbia, R. (2015), "The links between energy consumption, financial development, and economic growth in Lebanon: evidence from cointegration with unknown structural breaks", *Journal of Energy*.

Acar, S. and Aşıcı, A.A. (2017), "Nature and economic growth in Turkey: what does ecological footprint imply?", *Middle East Development Journal*, Vol. 9 No. 1, pp. 101-115.

Acheampong, A.O. (2018), "Economic growth, CO2 emissions and energy consumption: what causes what and where?", *Energy Economics*, Vol. 74, pp. 677-692.

Adedoyin, F.F., Gumede, M.I., Bekun, F.V., Etokakpan, M.U. and Balsalobre-lorente, D. (2019), "Modelling coal rent, economic growth and CO2 emissions: does regulatory quality matter in BRICS economies?", *The Science of the Total Environment*, 136284.

Ahmed, R., Sabau, G. and Haghiri, M. (2019), "The long-run relationship between economic growth and environmental quality", *Asian Journal of Agricultural Extension, Economics and Sociology*, pp. 1-10.

Akbostancı, E., Türüt-Aşık, S. and Tunç, G.İ. (2009), "The relationship between income and environment in Turkey: is there an environmental Kuznets curve?", *Energy Policy*, Vol. 37 No. 3, pp. 861-867.

Al-mulali, U., Fereidouni, H.G. and Lee, J.Y. (2014), "Electricity consumption from renewable and non-renewable sources and economic growth: evidence from Latin American countries", *Renewable and Sustainable Energy Reviews*, Vol. 30, pp. 290-298.

Ali, H.S., Zeqiraj, V., Lin, W.L., Law, S.H., Yusop, Z., Bare, U.A.A. and Chin, L. (2019), "Does quality institutions promote environmental quality?", *Environmental Science and Pollution Research*, Vol. 26 No. 11, pp. 10446-10456.

Alola, A.A. (2019a), "The trilemma of trade, monetary and immigration policies in the United States: accounting for environmental sustainability", *The Science of the Total Environment*, Vol. 658, pp. 260-267.

Alola, A.A. (2019b), "Carbon emissions and the trilemma of trade policy, migration policy and health care in the US", *Carbon Management*, Vol. 10 No. 2, pp. 209-218.

Alola, A.A., Bekun, F.V. and Sarkodie, S.A. (2019a), "Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe", *The Science of the Total Environment*, Vol. 685, pp. 702-709.

Alola, A.A., Yalçiner, K., Alola, U.V. and Saint Akadiri, S. (2019b), "The role of renewable energy, immigration and real income in environmental sustainability target. Evidence from Europe largest states", *The Science of the Total Environment*, Vol. 674, pp. 307-315.

Altıntaş, H. and Kassouri, Y. (2020), "Is the environmental Kuznets Curve in Europe related to the per-capita ecological footprint or CO2 emissions?", *Ecological Indicators*, Vol. 113, 106187.

Apergis, N. and Payne, J.E. (2009), "Energy consumption and economic growth: evidence from the Commonwealth of Independent States", *Energy Economics*, Vol. 31 No. 5, pp. 641-647.

Asongu, S.A., Agboola, M.O., Alola, A.A. and Bekun, F.V. (2020), "The criticality of growth, urbanization, electricity and fossil fuel consumption to environment sustainability in Africa", *The Science of the Total Environment*, Vol. 712, 136376.

Aydın, C. and Esen, Ö. (2017), "The validity of the environmental Kuznets Curve hypothesis for CO2 emissions in Turkey: new evidence from smooth transition regression approach", *Mustafa Kemal University Journal of Social Sciences Institute*, Vol. 14 No. 39, pp. 101-116.

Balibey, M. (2015), "Relationships among CO2 emissions, economic growth and foreign direct investment and the EKC hypothesis in Turkey", *International Journal of Energy Economics and Policy*, Vol. 5 No. 4, pp. 1042-1049.

Bekun, F.V., Alola, A.A. and Sarkodie, S.A. (2019), "Toward a sustainable environment: nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries", *The Science of the Total Environment*, Vol. 657, pp. 1023-1029.

Belke, A., Dobnik, F. and Dreger, C. (2011), "Energy consumption and economic growth: new insights into the cointegration relationship", *Energy Economics*, Vol. 33 No. 5, pp. 782-789.

Ben Jebli, M., Ben Youssef, S. and Apergis, N. (2014), "The dynamic linkage between CO2 emissions, economic growth, renewable energy consumption, number of tourist arrivals and trade", MPRA Paper 57261, University Library of Munich.

Bilgen, S. (2016), "The status of primary fossil energy resources in Turkey", *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, Vol. 38 No. 23, pp. 3478-3483.

Bilgili, F., Koçak, E. and Bulut, Ü. (2016), "The dynamic impact of renewable energy consumption on CO2 emissions: a revisited Environmental Kuznets Curve approach", *Renewable and Sustainable Energy Reviews*, Vol. 54, pp. 838-845.

Bölük, G. and Mert, M. (2015), "The renewable energy, growth and environmental Kuznets curve in Turkey: an ARDL approach", *Renewable and Sustainable Energy Reviews*, Vol. 52, pp. 587-595.

Bulut, U. (2020), "Environmental sustainability in Turkey: an Environmental Kuznets Curve estimation for ecological footprint", *The International Journal of Sustainable Development and World Ecology*, pp. 1-11.

Chandio, A.A., Ozturk, I., Akram, W., Ahmad, F. and Mirani, A.A. (2020), "Empirical analysis of climate change factors affecting cereal yield: evidence from Turkey", *Environmental Science and Pollution Research*, Vol. 27 No. 11, pp. 11944-11957.

Cherniwchan, J. (2012), "Economic growth, industrialization, and the environment", *Resource and Energy Economics*, Vol. 34 No. 4, pp. 442-467.

Climate Change Performance Index-CCPI (2016), available at https://ccpi.org/countries/.

Danish, U.R. and Salah-Ud-Din, K. (2020), "Relationship between energy intensity and CO2 emissions: does economic policy matter?". doi: 10.1002/sd.2098.

Destek, M.A. and Sarkodie, S.A. (2019), "Investigation of environmental Kuznets curve for ecological footprint: the role of energy and financial development", *The Science of the Total Environment*, Vol. 650, pp. 2483-2489.

Direkci, T. and Govdeli, T. (2016), "CO2 emission, energy consumption, economic growth and tourism for turkey: evidence from a cointegration test with a structural break", *International Journal of Management and Economics Invention*, Vol. 2 No. 12, pp. 1145-1155.

Dogan, E. and Inglesi-Lotz, R. (2020), "The impact of economic structure to the environmental Kuznets curve (EKC) hypothesis: evidence from European countries", *Environmental Science and Pollution Research*, Vol. 27 No. 11, pp. 12717-12724.

Dogan, N. (2016), "Agriculture and Environmental Kuznets Curves in the case of Turkey: evidence from the ARDL and bounds test", *Agricultural Economics*, Vol. 62 No. 12, pp. 566-574.

Elgin, C. and Öztunalı, O. (2014), "Environmental Kuznets curve for the informal sector of Turkey (1950-2009)", *Panoeconomicus*, Vol. 61 No. 4, pp. 471-485.

Esso, L.J. (2010), "Threshold cointegration and causality relationship between energy use and growth in seven African countries", *Energy Economics*, Vol. 32 No. 6, pp. 1383-1391.

Fæhn, T. and Bruvoll, A. (2009), "Richer and cleaner—At others' expense?", *Resource and Energy Economics*, Vol. 31 No. 2, pp. 103-122.

Farhani, S. and Balsalobre-Lorente, D. (2020), "Comparing the role of coal to other energy resources in the environmental Kuznets curve of three large economies", *The Chinese Economy*, Vol. 53 No. 1, pp. 82-120.

Gökmenoğlu, K. and Taspinar, N. (2016), "The relationship between CO2 emissions, energy consumption, economic growth and FDI: the case of Turkey", *Journal of International Trade and Economic Development*, Vol. 25 No. 5, pp. 706-723.

Gozgor, G. and Can, M. (2016), "Export product diversification and the environmental Kuznets curve: evidence from Turkey", *Environmental Science and Pollution Research*, Vol. 23 No. 21, pp. 21594-21603.

Grossman, G. and Krueger, A.B. (1993), *Environmental Impacts of a North American Free Trade Agreement, the US-Mexico Free Trade Agreement*, MIT Press, Cambridge, Massachusetts.

Güçlü, M. (2016), "The environmental Kuznets curve for Turkish nuts-3 regions: a spatial econometric analysis", *Inclusive and Sustainable Development and the Role of Social and Solidarity Economy*, Vol. 67.

Hepbasli, A. (2004), "Coal as an energy source in Turkey", *Energy Sources*, Vol. 26 No. 1, pp. 55-63.

Ibrahim, M.H. and Law, S.H. (2015), "Institutional quality and CO2 emission–trade relations: evidence from sub-Saharan Africa", *South African Journal of Economics*, Vol. 84, pp. 323-340, doi: 10.1111/saje.12095.

International Energy Agency (2019), "Turkey", available at https://www.iea.org/countries/turkey (accessed 12 July 2020).

Joshua, U. and Alola, A.A. (2020), "Accounting for environmental sustainability from coal-led growth in South Africa: the role of employment and FDI", *Environmental Science and Pollution Research*, pp. 1-11.

Kasman, A. and Duman, Y.S. (2015), "CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: a panel data analysis", *Economic Modelling*, Vol. 44, pp. 97-103.

Katircioğlu, S. and Katircioğlu, S. (2018), "Testing the role of urban development in the conventional environmental Kuznets curve: evidence from Turkey", *Applied Economics Letters*, Vol. 25 No. 11, pp. 741-746.

Katircioğlu, S.T. and Taşpinar, N. (2017), "Testing the moderating role of financial development in an environmental Kuznets curve: empirical evidence from Turkey", *Renewable and Sustainable Energy Reviews*, Vol. 68, pp. 572-586.

Kaya, M.G. and Kaya, P.H. (2017), "Environmental Kuznets curve and Turkey: an ARDL approach", *International Conference on Applied Economics*, Springer, Cham, pp. 223-234.

Kaygusuz, K. (2009), "Energy and environmental issues relating to greenhouse gas emissions for sustainable development in Turkey", *Renewable and Sustainable Energy Reviews*, Vol. 13 No. 1, pp. 253-270.

Koçak, E. and Şarkgüneşi, A. (2018), "The impact of foreign direct investment on CO 2 emissions in Turkey: new evidence from cointegration and bootstrap causality analysis", *Environmental Science and Pollution Research*, Vol. 25 No. 1, pp. 790-804.

Kuznets, S. (1955), "Economic growth and income inequality", *The American Economic Review*, Vol. 45 No. 1, pp. 1-28.

Kwiatkowski, D., Phillips, P.C., Schmidt, P. and Shin, Y. (1992), "Testing the null hypothesis of stationarity against the alternative of a unit root", *Journal of Econometrics*, Vol. 54 Nos 1-3, pp. 159-178.

Le, T.H., Chang, Y. and Park, D. (2019), "Economic development and environmental sustainability: evidence from Asia", *Empirical Economics*, Vol. 57 No. 4, pp. 1129-1156.

MacKinnon, J.G. (1996), "Numerical distribution functions for unit root and cointegration tests", *Journal of Applied Econometrics*, Vol. 11 No. 6, pp. 601-618.

McConnell, K.E. (1997), "Income and the demand for environmental quality", *Environment and Development Economics*, Vol. 2, pp. 383-399.

Munir, Q., Lean, H.H. and Smyth, R. (2020), "CO2 emissions, energy consumption and economic growth in the ASEAN-5 countries: a cross-sectional dependence approach", *Energy Economics*, Vol. 85, 104571.

Odhiambo, N.M. (2009), "Energy consumption and economic growth nexus in Tanzania: an ARDL bounds testing approach", *Energy Policy*, Vol. 37 No. 2, pp. 617-622.

Oh, W. and Lee, K. (2004), "Causal relationship between energy consumption and GDP revisited: the case of Korea 1970–1999", *Energy Economics*, Vol. 26 No. 1, pp. 51-59.

Onifade, S.T., Alola, A.A., Erdoğan, S. and Acet, H. (2021), "Environmental aspect of energy transition and urbanization in the OPEC member states", *Environmental Science and Pollution Research*, pp. 1-12.

Ozcan, B., Apergis, N. and Shahbaz, M. (2018), "A revisit of the environmental Kuznets curve hypothesis for Turkey: new evidence from bootstrap rolling window causality", *Environmental Science and Pollution Research*, Vol. 25 No. 32, pp. 32381-32394.

Özokcu, S. and Özdemir, Ö. (2017), "Economic growth, energy, and environmental Kuznets curve", *Renewable and Sustainable Energy Reviews*, Vol. 72, pp. 639-647.

Ozturk, I. (2010), "A literature survey on energy–growth nexus", *Energy Policy*, Vol. 38 No. 1, pp. 340-349.

Ozturk, I. and Acaravci, A. (2010), "CO2 emissions, energy consumption and economic growth in Turkey", *Renewable and Sustainable Energy Reviews*, Vol. 14 No. 9, pp. 3220-3225.

Ozturk, I. and Acaravci, A. (2013), "The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey", *Energy Economics*, Vol. 36, pp. 262-267.

Pao, H.T. and Tsai, C.M. (2010), "CO2 emissions, energy consumption and economic growth in BRIC countries", *Energy Policy*, Vol. 38 No. 12, pp. 7850-7860.

Pata, U.K. (2018), "The influence of coal and non-carbohydrate energy consumption on CO2 emissions: revisiting the environmental Kuznets curve hypothesis for Turkey", *Energy*, Vol. 160, pp. 1115-1123.

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001), "Bounds testing approaches to the analyses of level relationships", *Journal of Applied Econometrics*, Vol. 16, pp. 289-326.

Rathnayaka, R.K.T., Seneviratna, D.M.K.N. and Long, W. (2018), "The dynamic relationship between energy consumption and economic growth in China", *Energy Sources, Part B: Economics, Planning and Policy*, Vol. 13 No. 5, pp. 264-268.

Saint Akadiri, S., Alola, A.A. and Akadiri, A.C. (2019), "The role of globalization, real income, tourism in environmental sustainability target. Evidence from Turkey", *The Science of the Total Environment*, Vol. 687, pp. 423-432.

Saint Akadırı, S., Alola, A.A. and Usman, O. (2021), “Energy mix outlook and the EKC hypothesis in BRICS countries: a perspective of economic freedom vs. economic growth”, *Environmental Science and Pollution Research*, pp. 1-5.

Salahuddin, M. and Gow, J. (2019), “Effects of energy consumption and economic growth on environmental quality: evidence from Qatar”, *Environmental Science and Pollution Research*, Vol. 26 No. 18, pp. 18124-18142.

Seker, F., Ertugrul, H.M. and Cetin, M. (2015), “The impact of foreign direct investment on environmental quality: a bounds testing and causality analysis for Turkey”, *Renewable and Sustainable Energy Reviews*, Vol. 52, pp. 347-356.

Shahbaz, M. and Sinha, A. (2019), “Environmental Kuznets curve for CO2 emissions: a literature survey”, *Journal of Economics Studies*.

Stern, D.I. (2004), “The rise and fall of the environmental Kuznets curve”, *World Development*, Vol. 32 No. 8, pp. 1419-1439.

Tunçsiper, B. and Uçar, B. (2017), “Validity test of environmental Kuznets curve for Turkey: Granger causality analysis”, *International Journal of Social Sciences and Education Research*, Vol. 3 No. 2, pp. 657-666.

Tutulmaz, O. (2015), “Environmental Kuznets Curve time series application for Turkey: why controversial results exist for similar models?”, *Renewable and Sustainable Energy Reviews*, Vol. 50, pp. 73-81.

Umar, M., Ji, X., Kirikkaleli, D. and Alola, A.A. (2020), “The imperativeness of environmental quality in the United States transportation sector amidst biomass-fossil energy consumption and growth”, *Journal of Cleaner Production*, 124863.

Usman, O., Alola, A.A. and Sarkodie, S.A. (2020), “Assessment of the role of renewable energy consumption and trade policy on environmental degradation using innovation accounting: evidence from the US”, *Renewable Energy*, Vol. 150, pp. 266-277.

Uzar, U. and Eyuboglu, K. (2019), “The nexus between income inequality and CO2 emissions in Turkey”, *Journal of Cleaner Production*, Vol. 227, pp. 149-157.

Wang, M.L., Wang, W., Du, S.Y., Li, C.F. and He, Z. (2020), “Causal relationships between carbon dioxide emissions and economic factors: evidence from China”, *Sustainable Development*, Vol. 28 No. 1, pp. 73-82.

Wang, S., Li, G. and Fang, C. (2018), “Urbanization, economic growth, energy consumption, and CO2 emissions: empirical evidence from countries with different income levels”, *Renewable and Sustainable Energy Reviews*, Vol. 81, pp. 2144-2159.

Yavuz, N.Ç. (2014), “CO2 emission, energy consumption, and economic growth for Turkey: evidence from a cointegration test with a structural break”, *Energy Sources, Part B: Economics, Planning and Policy*, Vol. 9 No. 3, pp. 229-235.

Yurttagüler, İ. and Kutlu, S. (2017), “An econometric analysis of the environmental Kuznets curve: the case of Turkey”, *Alphanumeric Journal*, Vol. 5 No. 1, pp. 115-126.

Zambrano-Monserrate, M.A., Valverde-Bajaña, I., Aguilar-Bohórquez, J. and Mendoza-Jiménez, M. (2016), “Relationship between economic growth and environmental degradation: is there an environmental evidence of Kuznets curve for Brazil?”, *International Journal of Energy Economics and Policy*, Vol. 6 No. 2, pp. 208-216.

Appendix

Indicator Name	Abbreviation	Measurement	Source
Carbon Emissions	CEM	Million tonnes of CO_2	BP
Gross Domestic Product per capita	GDPC	Constant 2010 US Dollars	WDI
Coal Consumption	COALC	Mtoe	BP
Oil Consumption	OILC	Mtoe	BP

Correlation matrix

Variables	CEM	GDPC	COALC	OILC
CEM	1.000			
GDPC	0.948*	1.000		
COALC	0.995*	0.945*	1.000	
OILC	0.957*	0.836*	0.942*	1.000

Note(s): The WDI, BP and MTOE are respectively the World Bank Development Indicator, British Petroleum and Millions of tonnes of oil equivalent. Additionally, the * indicates the 1% statistical significant level
Source(s): Authors' computation

Table A1. Variable description and measurement unit

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