



# Analysis of CO<sub>2</sub> emissions and energy consumption by sources in MENA countries: evidence from quantile regressions

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## Abstract

The development of economies and energy usage can significantly impact the carbon dioxide (CO<sub>2</sub>) emissions in the Middle East and North Africa (MENA) countries. Therefore, this study aims to analyze the factors that determine CO<sub>2</sub> emissions in MENA under the environmental Kuznets curve (EKC) framework by applying novel quantile techniques on data for CO<sub>2</sub> emissions, real income, renewable and non-renewable energy consumption, and urbanization over the period from 1990 to 2015. The results from the estimations suggest that renewable energy consumption significantly reduces the level of emissions; furthermore, its impact increases with higher quantiles. In addition, non-renewable energy consumption increases CO<sub>2</sub> emissions, while its magnitude decreases with higher quantiles. The empirical results also confirm the validity of EKC hypothesis for the panel of MENA economies. Policymakers in the region should implement policies and regulations to promote the adoption and use of renewable energy to mitigate carbon emissions.

**Keywords** Carbon dioxide emissions · Renewable energy · Non-renewable energy · MENA countries

## Introduction

A number of studies in the extant literature have examined the effects of economic development on the environment (Adedoyin et al. 2020; Hu et al. 2020; Munir et al. 2020; Sun et al. 2020). Many of these studies rely on the environmental Kuznets curve (EKC) theory to find the link between economic growth and environmental degradation. Depending on the state of the economy, this relationship can take an inverted U-shaped or U-shaped pattern. In detail, the inverted U-shaped model suggests that income increases environmental degradation until it reaches the threshold level and then starts to decrease the pollution (Waqih

et al. 2019). On the other hand, a U-shaped model proposes an opposite relationship between income and environmental degradation (Xu et al. 2020).

Increases in the level of emissions and global warming around the world have created significant challenges for governments which try to manage it through different strategies. Since many researchers have highlighted the importance of carbon emissions to climate change (Nathaniel et al. 2020; Li et al. 2020; Fan et al. 2019), one strategy can be to increase the share of renewable energy in the energy mix (Anwar et al. 2021; Balsalobre-Lorente and Leitão 2020; Ikram et al. 2020). This issue has been taken into full consideration by many countries through the Kyoto Protocol of 1997, the Paris Agreement of 2015, and the United Nations Conference of 2017. The outcomes of these events have created important policies and practices to reduce environmental problems and global warming. This research aligns with the agenda of the United Nations' Sustainable Development Goals 2030, particularly Goal 7: Affordable and clean energy, Goal 12: Responsible consumption and production, and Goal 13: Climate action (Sustainable Development Goals—United Nations 2020 <https://sdgs.un.org/goals>). Overall, this paper discusses the implementation of SDGs' aims in the MENA countries considering cleaner and innovative sources of energy (renewable energy) to sustain the quality of the environment.

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According to the World Bank (2020), Middle East and North African (MENA) countries have a large reserve of natural gas and oil compared with other regions. These countries have 45% of global natural gas reserves and 60% of the global oil reserves (BP 2018). On the other hand, most countries in the region paid more attention to the energy policies and to stimulate more investments on renewable energy. According to the report of Asnani (2016), the share of renewable energy utilization out of total consumption in the Middle East is anticipated to grow from 2% in 2010 to 12% by 2035.

Recently, the COVID-19 pandemic has affected the energy sector negatively as the demand on energy reduced sharply; this reduction slumped the oil prices. The positive issues which appeared over the period of the pandemic were that CO<sub>2</sub> emissions have been cut due to the lower global production of goods and services and the cut in the tourism sector. Moreover, governments have increased their investment on renewable energy such as investing in green bonds (Oxford Business Group 2020). According to MENA countries, the OECD (2020) discusses the policies and methods to face COVID-19 crisis effects. The report shows that governments of MENA countries have developed many policies and plans to support the economy, firms, and households. The report also concludes that the energy sector in MENA region has played a main role to support many facilities, e.g., supply chain (delivery) of healthcare products and distance working. The report suggests MENA countries should sustain energy like focusing more on the transitions using cleaner energy, which would reduce CO<sub>2</sub> and air pollution in MENA region.

Based on these considerations, this study aims to examine the effects of economic growth, non-renewable and renewable energy consumption, and urbanization on CO<sub>2</sub> emissions for the 15 MENA countries according to the EKC theory by using data from 1990 to 2015. To the best of our knowledge, this is the first attempt to study the effects of energy consumption on MENA economies by using the novel quantile regression approach proposed by Powell (2016). Furthermore, this research not only contributes to the literature that focuses on the effect on the environment of energy consumption by sources but also enriches the thin body of literature that applies quantile regression methods in the field. The advantages of this approach are discussed in the Methods section. This study will help policymakers in the region to implement accurate and reliable policy and regulations to handle the increased pollution levels.

The following section presents the literature review, while Section 3 explains the model and data. Section 4 discusses the methods and empirical results of the study. The final section concludes the study and considers various policy implications.

## Literature review

Over the past decade, it has been discussed that carbon dioxide (CO<sub>2</sub>) emissions have been increasing worldwide. This

exacerbates climate change and results in many global environmental challenges and threats. For this reason, it is critical to study the main positive and negative determinants of CO<sub>2</sub>. The negative effects of air pollution could increase negative health effects as higher levels of pollution will increase the risk of diseases and the number of deaths. Based on this, countries have striven to mitigate CO<sub>2</sub> emissions through the use of renewable, alternative, and green energy production. The literature review is divided into two sections as follows:

### Previous studies on CO<sub>2</sub> for MENA region

Many studies have focused on CO<sub>2</sub> emissions in MENA countries (e.g., Abdallah and Abugamos 2017; Charfeddine and Kahia 2019; Magazzino and Cerulli 2019; Nathaniel et al. 2020; Al-Mulali et al. 2013). However, in the literature, there are many studies that have found the main causes of air pollution (CO<sub>2</sub> emissions). In the MENA countries, the results of previous studies found that renewable energy consumption explains CO<sub>2</sub> slightly. This means that MENA countries have not yet fully developed environmental quality.

The most recent study on 13 MENA countries was conducted by Nathaniel et al. (2020). This study examined the effects of renewable and non-renewable energy consumption on the MENA region. The data in this study was determined using the Augmented Mean Group algorithm. The primary findings of the study indicate that the degradation of the environment has been affected positively through financial development, economic growth, and urbanization. The surprising findings indicate that renewable energy has an insignificant correlation with the quality of environment, but non-renewable energy added to environmental degradation significantly.

A study on 18 MENA countries by Magazzino and Cerulli (2019) on the period from 1971 to 2013 aimed to find the association between carbon emissions, GDP, and energy consumption in the MENA region. The approach to analyzing the data for this study is the responsiveness scores (RS). According to RS results, a significant and positive correlation was found between GDP per capita and energy consumption. In contrast, trade and urban population influence CO<sub>2</sub> negatively. Another study on MENA countries by Shahbaz et al. (2019) identified the positive and negative determinants of CO<sub>2</sub> emissions over the period 1990–2015. The data of this study was analyzed through the generalized method of moments (GMM). The results of the GMM suggest that economic development (that has both inverted U- and N-shaped model and satisfies EKC hypotheses), foreign direct investment (FDI), and biomass energy determine CO<sub>2</sub> emissions significantly and positively. The conclusion of the study strongly suggests designing more effective trade and energy usage policies and regulations in MENA countries. However, Charfeddine and Kahia (2019) examine the effects of renewable energy consumption and

financial development on CO<sub>2</sub> emissions and economic growth for 24 MENA countries during the period 1980–2015. The finding of this study proposes that renewable energy consumption and financial development slightly explain both measures of CO<sub>2</sub> emissions and economic growth. This shows that the financial and renewable energy sectors need improvements to increase the quality of the environment and to grow the economies of MENA countries.

Abdallah and Abugamos (2017) also analyze the impact of urbanization on CO<sub>2</sub> emissions for 20 MENA countries for the period 1980–2014 examining the EKC. The GDP per capita, total population, and energy intensity increased the emissions of CO<sub>2</sub> significantly and positively, while urbanization has insignificant correlation with CO<sub>2</sub> emissions. Al-Mulali et al. (2013) explore the association between energy consumption, urbanization, and CO<sub>2</sub> emissions through the period 1980–2009 for 20 countries in the MENA region using the dynamic ordinary least squares (OLS) technique. The results of OLS suggest that over the period of the study, higher levels of urbanization and energy usage lead to more environmental degradation. These findings encourage MENA countries’ policymakers to slow down the growth of urbanization and find cleaner energy sources to save the environment from pollutions (e.g., CO<sub>2</sub> emissions).

**Previous studies on CO<sub>2</sub> for other regions**

Anser et al. (2020) tested the influence of non-renewable energy consumption (like fossil fuels), renewable energy consumption, and economic development (industrial) on pollution in Latin America and the Caribbean, which are considered developing economies. The period of this study covers 1990–2015, and it utilized the two-step system generalized method of moments as a statistical model. The outcomes of this study show that economic growth, competitive industrial growth, annual per capita fossil fuel consumption, and urbanization impacted CO<sub>2</sub> emissions significantly and positively. In contrast, the squared economic growth and renewable energy consumption significantly increased the quality of the environment through reducing CO<sub>2</sub> emissions.

Fan et al. (2019) test the factors of carbon emissions in Belt and Road countries for the 2000–2014 period. The findings suggest that gross domestic production (GDP) derive the increase of carbon dioxide emissions that are produced from energy consumption. In addition, technological changes also have a positive impact on CO<sub>2</sub> emissions. Concentrating on the European Union, Dogan and Seker (2016a) identify the main determinants of CO<sub>2</sub> emissions for the 1980–2012 periods. In particular, this study examines the effect of renewable and non-renewable energy real income and trade openness on CO<sub>2</sub> emissions. The statistical model of testing the correlations in this study is the EKC. The main results of EKC

propose that renewable energy and trade are important to lowering the rates of pollution (CO<sub>2</sub>).

Focusing on OECD countries, Balsalobre-Lorente et al. (2019) investigate the impacts of economic growth, energy innovation, and corruption on pollution (CO<sub>2</sub> emissions) covering the period of 1995–2016. This research uses the EKC to explore the association between economic development and carbon emissions. The findings of this study conclude that economic growth and corruption decreased the quality of the environment significantly. By contradiction, energy innovation influences the environment in positive way. This encourages policymakers to adopt more innovative energy channels and implementing more anti-corruption policies and regulations to save the environment in the short and long terms.

In conclusion, most past studies argued that using renewable energy sources could mitigate the emission of carbon dioxide significantly and effectively. By contrast, most previous studies confirmed a negative and significant association between economic growth and employing non-renewable energy sources and CO<sub>2</sub> emissions. Based on the literature review, we can examine the effects of GDP, renewable energy, and non-renewable energy on CO<sub>2</sub> emissions through the following hypotheses:

*H1: There is a positive association between CO<sub>2</sub> and GDP in MENA countries.*

*H2: There is a negative association between CO<sub>2</sub> and GDP<sup>2</sup> in MENA countries.*

*H3: There is a negative association between CO<sub>2</sub> and renewable energy in MENA countries.*

*H4: There is a positive association between CO<sub>2</sub> and non-renewable energy in MENA countries.*

**Empirical model and data**

This study uses the EKC framework in Eq. (1), following recent studies by Chen et al. (2019) and Usama et al. (2020), to analyze the impacts of economic growth, renewable energy consumption, non-renewable energy consumption, and urbanization on the level of CO<sub>2</sub> emissions:

$$CO2_{it} = \beta_0 + \beta_1GDP_{i,t} + \beta_2GDP^2_{i,t} + \beta_3RE_{i,t} + \beta_4NRE_{i,t} + \beta_5URB_{i,t} + \varepsilon_{i,t} \tag{1}$$

*i* and *t* represent country and time dimension in the panel of countries. Regarding the variables, CO<sub>2</sub> is the carbon dioxide emissions per capita; GDP is the economic growth measured by the real gross domestic product per capita in constant 2010 \$; REN denotes renewable energy consumption which

includes energy consumption from the following resources: hydro, solid biofuels, wind, solar, liquid biofuels, biogas, geothermal, marine, and waste; NRE is the non-renewable energy consumption, which includes energy consumption from these sources: coal, nuclear energy, natural gas, and oil; URB is urbanization which indicates the percentage of population living in urban areas. The annual data is from 1990 to 2015 and represents 15 MENA countries from the World Bank's World Development Indicators (World Bank 2020). These 15 countries are Algeria, Egypt, Ethiopia, Iran, Iraq, Israel, Jordan, Lebanon, Morocco, Saudi Arabia, Sudan, Tunisia, Turkey, United Arab Emirates, and Yemen. It is thus essential to express that this study covers the maximum number of countries with the largest time period for the analyzed variables. The data have been converted into natural logarithms.

To better understand the data, this study reports descriptive statistics of CO<sub>2</sub> emissions, real GDP, renewable energy consumption, non-renewable energy consumption, and urbanization. Table 1 illustrates the number of observations (15 countries \* 26 years), mean, median, minimum and maximum values of data, and skewness and kurtosis statistics. It can be claimed that the analyzed variables are not symmetric and normally distributed because the values of skewness statistics are different than zero. In addition, values have heavier tails than a normal distribution because the kurtosis statistics are greater than +3. Finally, descriptive statistics demonstrate the heterogeneity of the data, which suggests the use of panel quantile regression method for reliable empirical results.

## Methods and empirical results

Table 2 depicts the outcomes from the Im-Pesaran-Shin (IPS) panel unit root test following Im et al. (2003) and cross-sectionally augmented IPS (CIPS) following Pesaran (2007). The latter test evaluates the heterogeneity and cross-sectional dependence of the series that might not be captured by the first-generation IPS unit root test. According to the test results, the null hypothesis stating the variables are not stationary was rejected, and the series are stationary at their differences.

The unit root results ensure that the variables are integrated, so the analysis should proceed with panel cointegration tests. Table 3 demonstrates the results from three panel

**Table 2** Results from panel unit root tests

	Level		First difference	
	CIPS	IPS	CIPS	IPS
CO <sub>2</sub>	-2.50	-0.86	-5.15**	-15.54**
GDP	-2.12	-0.31	-4.08**	-8.20**
REN	-2.41	-0.12	-4.75**	-10.86**
NREN	-2.34	-0.44	-4.89**	-12.31**
URB	-1.35	-0.66	-2.55**	-7.38**

Note: \*\* represents 1% level of significance.

cointegration tests: the Pedroni panel cointegration test (Pedroni 1999), the Kao panel cointegration test (Kao 1999), and the Westerlund cointegration test (Westerlund 2005). The last test is assumed to mitigate the impact of heterogeneity and cross-sectional dependence. The results of the cointegration tests indicate a cointegrating relationship between variables at a 1% statistical significance level.

This study adopts the novel quantile regression method developed by Powell (2016). The methodology is useful when the independent variables display varying effects at different points in the conditional distribution of the dependent variable (Dogan et al. 2020). The methodology provides a great advantage since the regression can accomplish conditional quantile estimation and estimates the behavior of each specific point in the conditional distribution. This methodology offers various advantages over classical regression methods. The quantile approach does not postulate a moment function (Zhu et al. 2016), and the outcomes of the analysis are robust, and the outliers do not have an impact on the results. The model is also advantageous in the sense of no conditional assumption about the distribution of the data (Sherwood and Wang 2016). Lastly, the model minimizes the sum of squares of the residuals by adopting the linear programming method (He et al. 2016). Despite the listed advantages, the model is ineffective in terms of estimating a large number of fixed effects and exhibits incidental parameter problems when  $T$  is small. Powell's (2016) quantile approach with fixed effects overcomes this issue and allows for nonadditive fixed effects. The panel quantile regression with fixed effects is as follows:

$$y_{it} = \alpha_i + \beta(q)x'_{it} + u_{it}$$

**Table 1** Descriptive statistics

Var.	#Obs.	Mean	Min.	Max.	Median	Std. dev.	Skewness	Kurtosis
CO <sub>2</sub>	390	0.89	-3.20	3.58	1.11	1.48	-0.83	3.63
GDP	390	8.33	5.10	11.14	8.24	1.31	-0.02	3.10
REN	390	6.72	2.19	9.66	7.20	2.02	-0.65	3.88
NREN	390	9.99	5.88	12.91	10.12	1.39	-0.63	3.75
URB	390	4.02	2.53	4.52	4.19	0.48	-1.36	4.08

**Table 3** Results from panel cointegration tests

	Westerlund test	Pedroni test	Kao test
Statistic	-1.95*	-4.06**	-2.79**
Probability	0.026	0.00	0.00

Note: \*\* and \* represent 1 and 5% levels of significance.

where  $i$  denotes the number of countries and  $t$  represents the time dimension.  $y$  stands as the dependent variable, while the vector  $x$  contains all independent variables.  $q$  denotes the quantile ( $0 < q < 1$ ) of the conditional distribution, and  $\alpha$  represents the presence of fixed effects.

Table 4 displays the results from the OLS model and Powell (2016)'s quantile regressions with nonadditive fixed effects. The results of both the OLS and quantile regressions support the existence of EKC hypothesis, with the exception of the lowest quantile. According to the OLS results, a 1% increase in GDP increases carbon emissions by 0.90%, and conversely, a 1% increase in squared GDP decreases emissions by 0.03% with 1% statistical significance. Therefore, the results of the OLS display an inverted U-shaped pattern, and the validity of an inverted U-shaped model of the EKC in MENA countries indicates that these countries reached a threshold level of economic growth and are moving towards a green growth phase in their production (Grossman and Krueger 1995).

Quantile regression results are provided for the selected quantiles of 0.10, 0.25, 0.50, 0.75, and 0.90 and provide a detailed analysis of the determinants of carbon emissions across the different quantiles of carbon emissions. The impact of economic growth on carbon dioxide emissions is positive and statistically significant at all quantiles except for the 0.10th quantile, and the effect of the growth on emissions is stronger at the high quantiles. The impact of squared economic growth is negative and statistically significant for all the quantiles other than the 0.10th quantile. Carbon emissions upsurge significantly along with growth, and the impact is higher in the higher quantiles. On the other hand, the sustained economic growth reduces the emissions

up to a certain level. Thus, the results depict an inverted U-shaped pattern for all the quantiles, and the turning points of the EKC are positioned at different levels. These findings are in consistent with the findings of previous studies (Dogan and Seker 2016b; Anwar et al. 2021).

According to the results of the OLS regression, the impact of renewable energy usage on carbon emissions was found to be statistically insignificant, whereas this impact was found to be statistically significant for all quantiles in quantile regressions. The impact of renewable energy increases across the quantiles, and the coefficient becomes higher for the 0.90th quantile, suggesting that renewable energy has a superior impact on higher carbon-emitting countries. The inverse impact of the renewable energy on carbon emissions is also supported by the previous literature (Lopez-Menendez et al. 2014; Shafiei and Salim 2014; Álvarez-Herranz and Balsalobre-Lorente 2015; Al-Mulali et al. 2016; Akram et al. 2020; Anwar et al. 2021).

The OLS and quantile regression results indicate a positive and statistically significant impact of non-renewable energy on emissions. This finding was also reported in Farhani and Shahbaz (2014) for MENA countries and in Boluk and Mert (2015) for Turkey. The OLS results indicate that with a 1% increase in non-renewable energy, consumption will rise by 0.63%. The outcomes of the panel quantile regression are interesting since the impact of non-renewable energy presents a decreasing trend when we move from the 0.10th quartile to the 0.90th quartile. The consumption of non-renewable energy upsurges carbon emissions in lower carbon-emitting countries than high carbon emitters. A higher coefficient of non-renewable energy than renewable energy is also reported for MENA countries in Farhani and Shahbaz (2014). This is due to the fact that renewable energy consumption remains lower; thus, the mitigating impact of renewable energy is still limited compared to non-renewable energy. The lower quantiles of the analysis might rely more on fossil fuels to achieve economic progress, which leads to a higher impact of non-renewable energy on carbon emissions (Shahbaz et al. 2017).

**Table 4** Results from panel quantile regression

	OLS	Quantile regression				
		q0.10	q0.25	q0.50	q0.75	q0.90
GDP	0.73***	0.54	0.20	0.47***	0.69***	0.89***
GDP <sup>2</sup>	-0.03**	-0.03	-0.01	-0.02***	-0.03***	-0.03**
REN	-0.01	-0.02*	-0.05***	-0.06***	-0.06***	-0.09***
NREN	0.61***	0.90***	0.80***	0.71***	0.68**	0.58***
URB	0.24**	0.59***	0.37***	0.33***	0.27***	0.10*
CONS	-10.35***	-12.97***	-9.61***	-9.92***	-10.43**	-9.71**

Note: \*\*\*, \*\*, and \* represent 1, 5 and 10% levels of significance.

Urbanization is found to influence the emissions positively in both the OLS and quantile regressions. According to the findings of the OLS model, if URB increases by 1%, it will intensify the carbon emissions by 0.23%. The results of the quantile regression show that the impact of URB is higher in lower quantiles, and this impact diminishes in lower quantiles. From the 0.10th quantile to the 0.90th quantile, the coefficient is 0.59, 0.37, 0.33, 0.27, and 0.10, respectively. Urbanization is a more dominant factor for lower carbon emitters, suggesting that urbanization is a major source of emissions. The finding is in consistence with Anser et al. (2020). The difference between quantiles might be explained with regional differences (Zhang and Lin 2012) and diverse development stages (Poumanyong and Kaneko 2010).

## Conclusion and policy implications

This paper has examined the determinants of carbon dioxide emissions by considering the impact of renewable and non-renewable energy consumption under the framework of the EKC using OLS and Powell's (2016) panel quantile approach in MENA countries for the period between 1990 and 2015. The panel quantile regression method provides a deeper understanding of the differences across different carbon emission levels, thus allowing us to interpret the relationship between carbon dioxide emissions and the determining factors at different emission levels.

The results of the analysis validate the existence of EKC and depict an inverted U-shaped pattern in both the OLS and across quantiles. The sustained economic growth of the countries increases carbon emissions up to a certain threshold and then impedes the emissions. The outcomes of the panel quantile analysis provided valuable results by positioning a different threshold level across different emission levels. It is evident that for higher carbon-emitting countries, a higher level of economic growth is necessary to mitigate the emissions. The coefficients of GDP in EKC curve are 0.54, 0.20, 0.47, 0.69, and 0.89 for the 10th, 25th, 50th, 75th, and 90th quantiles, respectively, suggesting that lower carbon-emitting countries achieve to overcome the deteriorating effects of economic growth at lower levels of GDP per capita growth. This finding is not only significant for MENA countries but may also provide valuable implications for other countries.

In alignment with the previous studies, renewable energy consumption has a statistically significant negative affect on carbon emissions. This result is also valid for all quantiles, and this impact increases in higher carbon-emitting countries; however, OLS failed to report a significant relationship. The outcomes of the panel quantile method demonstrate that the substitution to non-renewable energy is a significant factor to diminish environmental degradation. However, for MENA countries, there is more room to adopt greener sources of

energy to decrease the emissions in these countries due to scale effect. Countries should pursue strategies to find cheaper approaches to intensify the usage and sources of renewable energy adoption. The insignificant results of the OLS analysis also point that future research should adopt quantile approaches, since it provides robust results when the data displays heterogeneity.

Non-renewable energy consumption on the other hand increases carbon emissions significantly in both of the models. The non-renewable energy displays a higher coefficient than renewable sources, since the usage of renewable energy adoption remains modest in MENA countries and non-renewable energy dominates the energy usage. The impact of non-renewable energy from lower quantiles to higher quantiles decreases; non-renewable energy consumption has lower detrimental impact on environmental quality in higher carbon-emitting countries. The decrease of the coefficient of non-renewable energy sources in higher quantiles can be attributed to the increase of renewable energy consumption in the energy mix in these countries.

Considering the findings of the paper, MENA countries should focus on policies to promote the adoption and usage on renewable energy sources to prevent environmental deterioration. This is particularly crucial for higher carbon-emitting countries; thus, the promotion of research and investment activities to increase the production and consumption of renewable energy sources should be a first priority to decrease carbon emissions. Despite the high costs of renewable energy, governments should promote investments in different sources of clean energy, such as wind and solar. Since renewable energy is of crucial importance in decreasing emissions, it is essential to design regulations to hinder environmental degradation. Moreover, countries should allocate more funds for technological advancements and research to encourage the shift from non-renewable sources to renewable and cleaner energy sources. Furthermore, policymakers in these countries should design and implement policies that focus on economic growth to achieve a consistent decline in carbon emissions. Growth-oriented economic policies upsurge the usage of cleaner sources and might improve reductions in environmental degradation. The limitation of the paper is that it ponders the existence of a U-shaped pattern in EKC framework for MENA countries, given their economic growth status. Further research might seek for an N-shaped relationship, if there is an augmentation of the economic growth in these countries. Moreover, the extension of the analysis is possible by investigating the impacts of COVID-19 on the altering energy demand. It is evident that energy consumption fell sharply, with the shutdown of businesses, diminishing air travel, whereas the usage of public transport diminished dramatically, and the usage of surgical masks and their production and impacts on environment might have very adverse effects. Thus, we believe the extension of the data will shed light on those questions.

## Appendix

### List of the countries in the analysis

Algeria, Egypt, Ethiopia, Iran, Iraq, Israel, Jordan, Lebanon, Morocco, Saudi Arabia, Sudan, Tunisia, Turkey, United Arab Emirates, Yemen

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**Data availability** The data that support the findings of this study are openly available on request.

### Declarations

**Ethical approval and consent to participate** The authors state that they have no known competing financial interests or personal relationships, which seem to affect the work reported in this article. We declare that we have no human participants, human data, or human issues.

**Consent for publication** Authors do not have any individual person's data in any form.

**Competing interest** The authors declare no competing interest.

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