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Do natural resources and economic components exhibit differential quantile environmental effects?

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Abstract

In view of the resource curse assumption, the environmental aspects of resource utilization are arguably posing more dangers to human existence. In the Middle East and North Africa (MENA) region, the region that holds more than 60% and 50% of the world's oil and gas reserves respectively, the need to examine the contribution of natural resources to environmental quality among other factors cannot be overemphasized. By leveraging on the novelty of observing the differential impact of natural resources and other economic components such as income and primary energy utilizations across the quantiles of carbon emission, this study implements the quantile regression approach alongside other relevant techniques to analyze data between 1990 and 2018 for selected countries in the MENA region including Saudi Arabia, Iran, Kuwait, Qatar, Algeria, Morocco, Oman, Egypt, and the United Arab Emirates (UAE). The result posits that natural resource utilization generally hampers the environment across the quantiles. However, this negative effect decreases until the 50th quantile before starting to rise again toward the upper quantiles. Additionally, primary energy utilization and globalization respectively worsen and improve environmental quantile, especially toward the upper quantiles while income affirms the inverted U-shaped hypothesis across the entire quantiles. Moreover, there is a statistically significant one-way directional causality from natural resources, economic expansion, primary energy use, and globalization to carbon emission levels. Hence, the study offers environmentally friendly resource utilization policies to the MENA economies and other resource-rich states by extension.

KEYWORDS
carbon emission, energy utilization, MENA, natural resources, quantile regression

1 | INTRODUCTION

The reliance of humans on natural resources is critical to boosting economic activities as natural resources are often exploited and refined into various components to bolster countries' economic and developmental targets. For instance, in the case of energy resources, refined outputs are often utilized to meet energy consumption demands for various purposes such as industrial activities, residential utilities, and transportation purposes among other uses. Resource utilization in turn often helps in accelerating various developmental projects, which are not only expected to raise national income alone but also help to boost citizens' general welfare condition. Hence, many studies have linked resource utilization to economic growth and the energy consumption aspect of resource utilization has gained more prominence in several empirical studies in this era of growing levels of globalization (Cai & Magazzino, 2019; Dingru et al., 2023; Kirikkaleli et al., 2021; Xiaojua et al., 2021). However, the environmental aspects of the rising energy resource utilization trends have also created more concerns in recent times as the increases in pollutant emissions levels have been associated with the reduction in the quality of life of people and an increase in various natural hazards alongside other notable environmental pollution challenges (Agboola et al., 2022; Alola & Onifade, 2022; Magazzino, 2019). The World Bank estimates that the world's total energy rent has been increasing significantly in the last four decades. In high-income countries, the total energy rent has grown more than double from about 0.77% of the gross domestic product (GDP) in 1970 to 1.57% of GDP in 2018. Similarly, in middle-income countries, the total energy rent increases from 2.43% to 4.18% of GDP while the rent rises from 5.28% to 10.84% of GDP in low-income countries during the same period. Thus, across various levels of economic development, total energy resource rents, which include natural gas, coal, mineral, and forest rents, have been increasing.

The observed rising trend of natural resource rent does not only indicate the increasing pace of natural resource exploration, but it also indicates the rising levels of conventional energy consumption that has led to the growing calls for a transition to an environmentally friendly resource utilization at a global level (Dogan et al., 2022; Ofori et al., 2023; Tzeremes et al., 2023). The increasing trend of natural resource rents and energy consumption have provided necessary support to the growth in global economic activities that have ushered in remarkable growth in the general welfare of the world population over the past few decades. The World Bank estimates that the world's average GDP per capita has tripled from $5551 in 1990 to $17,811 in 2019. This amount represents an increase of more than 200% growth in global income levels. Thus, the positive impacts of natural resource rents and energy consumption could be observed in a country's national welfare as income levels rise over time.

However, despite the undoubting importance of natural resources to a country's economic and development progress, the persistent dependency of humans on natural resource exploitation also invites some consequences. One of the major consequences relates to its impact on environmental quality as energy consumption and exploitation activities exacerbate pollution levels through an increase in greenhouse gas emissions. Available data from the

World Bank data shows that the emission level of one of the prominent greenhouse gases (carbon dioxide) has risen from around 3.039 metric tons per capita in 1960 to about 4.555 metric tons per capita in 2016, representing an increase of about 49.88% over the period.

Policymakers and environmentalists have been keen on the need to cut down on global emission levels due to the risks of future colossal damages from continuous emission levels in terms of climate change, health hazards of greenhouse gases, and other problems. On average, going by the World Bank emission data, although the trend of global carbon emission has been upward between 1960 and 2016, however, there are notable fluctuations in the dynamics of pollution from carbon dioxide levels as there are declines at some particular periods. For instance, between 1979 and 1998, there was a decline in carbon dioxide emissions from 4.572 metric tons per capita to 3.837 metric tons per capita. The emission trend later rose over the subsequent years to about 4.541 metric tons per capita in 2008 before another decline was witnessed in 2009. This volatility of carbon emissions as observed from the inconsistent trends, especially in the periods of decline does not necessarily signals the effectiveness of mitigating policies over the years. On the contrary, most of the periods of decline in emission levels coincide with periods of a slowdown in global economic activities.

Hence, there are growing studies in the modern literature that aims to address environmental pollution from emission levels. This study intends to contribute to the ongoing development of the literature by investigating the impact of natural resource rents and energy consumption on the environment. The study utilizes countries in the Middle East and North Africa (MENA) region as the region is very critical to the overall global energy supply stability given that some of the countries in the region house part of the largest known oil and gas reserves in the world. The sample was drawn from 1990 to 2018 for countries in the study including Saudi Arabia, Iran, Kuwait, Qatar, Algeria, Morocco, Oman, Egypt, and the United Arab Emirates (UAE). The explained environmental degradation variable in the study is carbon dioxide emission levels, which were expressed in terms of million tons of emission levels. As for the explanatory variables, the study includes natural resources rent, and primary energy consumption from each country while also accounting for individual countries' levels of income, and the impacts of globalization.

This study distinguishes itself from extant studies in terms of the methodology employed, namely the implementation of quantile regression (QR), which is to the best of our knowledge, yet to be applied for the specific case study in similar literature, and for the expanded sample framework that was understudied. As such, the findings from this study significantly help in expanding the literature for the MENA region. The QR methodology that is adopted for this study makes it possible to observe the impacts of the energy indicators in the countries at different quantiles thus providing a deeper insight into their significance to the environmental quality of the region at large. In addition to the QR method, the study also explored the mean estimates from the combination of the fully modified ordinary least squares (FMOLS) and the dynamic ordinary least squares (DOLS) approaches for wider analysis and robustness checks. To the best of our knowledge, few studies have utilized Middle East countries as a sample while using some other approaches such as in the cases of Tunisia and the United Arab Emirates (Ibrahim & Alola, 2020; Khan et al., 2021; Nathaniel et al., 2020; Shahbaz et al., 2014; Shahbaz et al., 2016; Shahbaz et al., 2020). Studies of this kind for the region are scanty in the literature and have mainly focused on the instrumentality of first-generation regression techniques that have been argued to be prone to spurious results owing to less accountability for the important issue of possible cross-sectional dependency among countries in a panel study.

This study takes the following structure: the first chapter is the introduction, which is then followed by the second chapter that encapsulates the literature review and the theoretical framework. The third chapter explains the methodology. The fourth section provides the estimation result and analysis. Finally, the last chapter (5) concludes the study.

2 | THE EXTANT LITERATURE REVIEW

Studies investigating the impact of natural resource rent and energy consumption are widespread. The studies are conducted using various samples, techniques, and variables. One major similarity shared across studies is the use of carbon dioxide emission as a proxy for environmental degradation impacts. However, the magnitude and impact direction across studies are mixed, and this motivates further studies to investigate similar topics in various economies. On one aspect, this section looks at the related studies, on the other aspect the theoretical perspective of the study is put forward here.

2.1 | Theoretical framework

Various theories can possibly explain the links between natural resource rents, energy consumption, and their environmental impacts. Among the notable theories is the externality theory, which was first conceptualized by Pigou (1924). Externality theory supports a negative relationship between natural resource rent and environmental quality, as well as between energy consumption and environmental quality. The theory of externality is strongly related to the welfare theorem. The first fundamental theorem of welfare economics ensures that efficient allocation can be achieved through a competitive equilibrium. With a competitive equilibrium, the market mechanism can work in a Pareto-efficient manner. However, market failure occurs when the competitive environment is violated such that externality results from the operations of economic activities outside of the market mechanism by the economic agents.

In the context of environmental degradation, a negative externality is often applied. That is when the exploration of natural resources is irresponsibly carried out amidst growing needs for energy consumption such that negative impacts are eventually exerted on the environment. When this occurs, social marginal costs are often higher than private marginal costs because of the resultant marginal damage. This situation causes inefficiency known as a deadweight loss. In compensating for the deadweight loss, policy intervention is necessary to incorporate marginal damage into the total damage, offset the social marginal cost, and eliminate the deadweight loss. The policy intervention can be given in the form of a carbon tax or fine to the liable companies or organizations.

Another related theory is the growth theory. This theory can also explain the relationship between natural resource rents, energy consumption, and environmental degradation. The growth theory from Solow (1956) explains that higher production must be accompanied by the growth of capital and/or labor. On the assumption of market clearing, production is equal to consumption. Hence, higher consumption is also dependent on higher capital accumulation and labor. In this regard, natural resource rent represents capital accumulation, while energy consumption basically represents labor because labor operates machines, which require energy use to function. Thus, as the population rises over time, consumer demand is also expected to rise thereby exerting pressure on the environment in a bid to match up with demand. If technology, which is represented as Solow residual in the growth equation, is not high enough to counterbalance the speed of natural resource exploration, the consequences of environmental degradation can be more pronounced. Therefore, going by the growth theory, low-income, and middle-income countries, and other technologically poor countries are more vulnerable to environmental degradation.

The neoclassical theory of investment of Jorgenson (1963) is another theory in which the nexus of natural resource rents, energy consumption, and environmental degradation can be conceptualized. According to this theory, firms would always push for higher capital accumulation until their marginal product of capital equals their real rental cost of capital. It is gainful to accumulate more and more capital in as much as the marginal product of capital is higher than the rental cost of capital. In this regard, the capital corresponds to labor, which is closely related to energy consumption, given that the number of labor employed is proportional to the number of machines operated. In the context of natural resource rent and energy consumption, firms will be more incentivized to exploit natural resources and consume energy (to support labor) as long as the cost of doing such thing is lower than the marginal product of capital which is generally in line with the profit motive of business. In a more aggressive push for gains, firms may even sideline the cost from expected social and environmental responsibilities thereby incurring just minimal private cost. In conclusion, amid many theories that can possibly rationalize the relationship among natural resource rents, energy consumption, and environmental degradation, only three theories have been provided in this study. However, it is good to note that these theories are usually closely linked to each other. For instance, the investment theory is close to the growth theory in terms of the usage of the capital accumulation approach.

2.2 | Review of extant empirical studies

Alam et al. (2016) investigate factors affecting environmental degradation in China, and they also incorporate other major emerging economies like Brazil, India, and Indonesia for a study that covers the period between 1970 and 2012. The dependent variable in the study is CO_2 emission, which represents environmental destruction. As for the independent variables, the study incorporates economic growth, energy consumption, and population growth. The study applies the ARDL version of the vector error correction model following Khan et al. (2005) and, Frimpong Magnus and Oteng-Abayie (2006). Based on the applied methodology, the study confirms that the increase in energy consumption positively corresponds to the rise in CO_2 emission.

In Pakistan, the link between energy consumption and environmental destruction was also investigated by Ali et al. (2021) for a sample range between 1975 and 2014. Similar to some other studies, this study also captures environmental degradation using carbon dioxide emission as a dependent variable, while the study includes economic growth, energy consumption, and inward foreign direct investment as independent variables accordingly. Similar to Alam et al. (2016), this study also implements the ARDL bound test following Pesaran et al. (2001). Based on the technique, the study demonstrates that fossil energy consumption is positively correlated with carbon dioxide emissions. In addition, the study also indicates that economic growth contributes to the rising environmental degradation in Pakistan during the sample period.

Additionally, Bilgili et al. (2016) investigated the impact of energy consumption on environmental degradation in 17 OECD countries using data from 1977 to 2010. The study grouped energy consumption into renewable and non-renewable components while relying on the use of FMOLS and DOLS as the primary estimation methods. Based on the estimation approach, the study demonstrates that renewable energy lowers environmental pollution. Moreover, the study also argues that economic growth adds to environmental degradation. This finding is similar to a more recent study from Erdoğan et al. (2021) and Ansari et al. (2021).

Similar to the duo of Bilgili et al. (2016), and Ansari et al. (2021), the study by Sharif et al. (2019) also classified energy consumption into renewable and non-renewable energy consumption while investigating the dynamic relationship between energy consumption and carbon emission. The study incorporates a sample of 74 countries between 1990 and 2015. The study also applies the FMOLS to test the long-run relationship between the variables. As for the short-run relationship, the study applies the heterogeneous panel non-causality test. Based on these two methods, the study demonstrates that non-renewable energy consumption heightens environmental degradation, while renewable energy use improves environmental quality.

Furthermore, Bekun et al. (2019) also investigate the links between energy consumption, natural resource rent, and environmental degradation in Europe. Precisely, the study utilizes a sample of 16 European countries in the period between 1996 and 2014. As for the independent variables, the study includes economic growth, natural resource rent, and energy consumption. Economic growth is proxied by real gross domestic product, while energy consumption in the study is divided into renewable energy consumption and non-renewable energy consumption, which is similar to Ansari et al. (2021). Using the panel pooled group-autoregressive distributive lag model as the method of analysis, the study demonstrates that natural resource rent and CO_2 emission are positively correlated. Furthermore, the study also argues that energy consumption is also significantly related to carbon dioxide emission. However, the two have the opposite impact on carbon dioxide emissions. That is, non-renewable energy consumption significantly increases carbon dioxide emission, while renewable energy consumption is pollutant-abating.

Moreover, Pata (2018) also investigates the long-run relationship between energy consumption and environmental degradation with the sample in Turkey during the period of 1971–2014. The energy consumption in his study refers to coal and noncarbohydrate energy consumption, while environmental degradation in the study refers to carbon emission, which is a dependent variable. In addition to energy consumption, the independent variables utilized in the study include economic growth, trade openness, urbanization, financial development, and industrialization. The study applies the autoregressive disturbed lag bounds testing approach as a method of analysis. Using such a method, the study demonstrates that coal consumption positively affects carbon dioxide emission, which means pollutant-inducing. On the other hand, noncarbohydrate energy consumption is pollutant-reducing. Furthermore, in addition to the nexus between energy consumption and carbon emission, the study also reveals that economic growth contributes to environmental degradation in the short run, but it reduces pollution in the long run after the country reaches an extreme level of income, which shares the characteristics of environmental Kuznets curve.

Notwithstanding, the relationship between natural resource rent and carbon emission was also explored by Shen et al. (2021) in the case of China. Precisely, the study utilizes 30 provinces in China as the study sample over the period of 1995–2017. In their study, energy consumption only refers to non-renewable energy consumption. Based on the cross-sectionally augmented autoregressive distributed lags (CS-ARDL) employed in the study, it is revealed that natural resource rent is positively associated with carbon emission, which means pollutant-inducing, both in the long run and short run. Likewise, the estimation also reveals that energy consumption is also positively associated with higher carbon emissions, both in the short and long run. Zhang et al. (2019) also investigate the nexus between energy consumption, carbon emission, and economic growth. The study also employs China as a sample but focuses mainly on China's agricultural sector between 1996 and 2015. The dependent variable and independent variables in this study are similar to those in Shen et al. (2021) but the model is in log-linear form rather than quadratic form as in Shen et al. (2021). The study employs the ARDL bounds test to estimate the short-run and long-run relationship between the variables and it was discovered that there is a significant unidirectional causal link between energy consumption and carbon emission, both in the short and long run.

The study of Gorus and Aydin (2019) provides a different result regarding the impact of energy consumption on carbon emissions in the long run. The study considers the case of MENA countries over the period between 1975 and 2014. The study applies a panel causality test and delivers the finding that there is no significant causal relationship between economic growth and carbon emission. Furthermore, the statistically significant relationship between energy consumption and carbon emission is only found in the short run, but it is not clear in the long run. Hence, there is a valid motivation for further investigations into relevant topics in various economies.

3 | EMPIRICAL PROCEDURES

This study focuses on assessing the impacts of natural resources rent and energy consumption on the environmental sustainability of the MENA region through the QR technique. Studies of this kind for the region are very scanty in the literature and have mainly focused on the instrumentality of first-generation regression techniques that are prone to spurious results owing to less accountability for the important issue of possible cross-sectional dependency among countries in a panel study. Aside from the benefit of accounting for likely cross-sectional dependency problems, the QR methodology that is adopted for this study makes it possible to observe the impacts of the energy indicators in the countries at different quantiles thus providing a deeper insight into their significance to the environmental quality of the region at large. Following the reported significance of globalization in recent environmental studies (Chishti et al., 2020; Le & Ozturk, 2020; Shahbaz et al., 2020; Van & Bao, 2018; Yilanci & Gorus, 2020; Yurtkuran, 2021), this study also incorporated the roles of globalization in the base model of the study while focusing on the environmental quality of the region vis-à-vis the roles of natural resource rent and energy consumption among the countries.

$$LnCO_{2it} = \alpha + \beta_1 LnRY_{it} + \beta_1 RY_{it}^2 + \beta_2 LnNUR_{it} + \beta_3 LnEGC_{it} + \beta_4 LnGLB_{it} + \mu_{it} \tag{1}$$

In the present study, the baseline equation depicting the important link between energy indicators and environmental quality for the region follows the specification in Equation (1), whereas the general information about the description of the variables in terms of the measurement and sources is provided in Table 1.

The current study utilized data between 1990 and 2018 from nine (9) Middle East and North African countries including Saudi Arabia, Iran, Kuwait, Qatar, Algeria, Morocco, Oman, Egypt, and the United Arab Emirates (UAE). The region is generally critical to the overall global energy supply stability given that many countries in the region house some of the largest known oil and gas reserves in the world. The decision on the choice of countries and sample frame was informed by data availability. The data were taken in natural logarithms and the summary statistics are presented with the correlation analysis in Table 2.

The information in Table 2 shows that both natural resource rent and income levels are correlated with carbon emission levels among the countries. While the former was positively correlated with carbon emission, the latter was negatively correlated with carbon emission. On the other hand, the positive correlation was insignificant for the case of energy consumption and globalization. The correlation analysis only provides some insights into the degree of relationship among variables but does not necessarily supply the needed estimates for terms of long-run analysis.

3.1 | Cross-sectional dependency test

Given the proximity in economic activities and the ties among the countries in the MENA region, we have ensured that the concerns about the issues of cross-sectional dependency (CD) are accounted for in this current study. This is done in a bid to facilitate the adoption of the right approaches in terms of subsequent empirical steps that would be carried out in the study. The importance of the CD test has been highlighted in recent studies (Im et al., 2003; Sharif et al., 2019; Shen et al., 2021; Wang et al., 2020), and bypassing the CD tests for such a study as this could expose empirical outcomes to challenges of estimates bias due to wrong selection of empirical tools. Thus, following current empirical studies, we utilized the Breusch and Pagan (1980) LM Test and the combined estimates from the Pesaran (2007) CD Test, and Pesaran (2015) LM Test (Baloch et al., 2021; Gyamfi et al., 2021; Onifade, 2022; Sharif et al., 2019). The outcomes of the CD test are detailed in the result discussion section.

3.2 | Panel unit root and cointegration analysis

To ascertain the degree of stationarity of the panel data, we utilized the Pesaran (2007) IPS (CIPS) second-generation unit root tests in line with the specifications in Equation (2). Where Δ is the difference operator and ε_{it} denotes the error term respectively. On the other hand, given the variable X_{it} that is been examined, φ_{it} represents the intercept term of the model while T denotes the time span.

$$\Delta Y_{it} = \Delta\varphi_{it} + \beta_i X_{it-1} + \rho_i T + \sum_{j=1}^{n} \theta_{ij} \Delta X_{i,t-j} + \varepsilon_{it} \tag{2}$$

The Pesaran (2007) IPS (CIPS) unit root test produces more reliable unit root estimates for panel variables in this kind of study compared to the application of the first-generation unit root approaches (Erdoğan et al., 2022; Gyamfi et al., 2021; Gyamfi et al., 2022; Onifade & Alola, 2022; Sharif et al., 2019). Subsequently, having established the

TABLE 1 General information about variables.

Variables	Measurement	Sources	Symbols
CO_2 emissions	Million tons of carbon dioxide	BP (2020)	CO_2
GDP per Capita	PPP (current international US$)	WDI (2020)	RY
Natural resources	Total natural resource rent (% of GDP)	WDI (2020)	NUR
Primary energy consumption	Gigajoule per capita	BP (2020)	EGC
Globalization	KOF globalization Index	KOF index (2020)	GLB

Source: The author's compilation using data sources from the British Petroleum Statistical Review of World Energy (BP, 2020), the World Bank Data World Development Indicators (2020), and the globalization index of the KOF Swiss Economic Institute (Gygli et al., 2019).

TABLE 2 Summary statistics and correlation analysis.

Variables	$LnCO_2$	LnRY	$LnRY^2$	LnNUR	LnEGC	LnGLB
Mean	1.977798	2.688170	7.558508	1.235773	2.141421	1.757247
Median	1.964578	2.759068	7.612455	1.396364	2.289959	1.767374
Maximum	2.808983	4.336934	18.80899	1.792035	3.057744	1.877987
Minimum	1.052529	1.510321	2.281069	−0.598936	1.075986	1.443740
SD	0.434199	0.577519	3.205804	0.522174	0.566053	0.080055
Skewness	0.026629	0.173540	0.992550	−1.953907	−0.199605	−1.112008
Observations	261	261	261	261	261	
Correlation matrix						
Variables	**$LnCO_2$**	**LnRY**	**$LnRY^2$**	**LnNUR**	**LnEGC**	**LnGLB**
$LnCO_2$	1					
p-value	–					
LnRY	−0.1024*	1				
p-value	(.0986)	–				
$LnRY^2$	−0.1620***	0.9865***	1			
p-value	(.0087)	(.0000)	–			
LnNUR	0.2120***	0.6602***	0.5692***	1		
p-value	(.0006)	(.0000)	(.0000)	–		
LnEGC	0.0689	0.7648***	0.7288***	0.7011***	1	
p-value	(.2667)	(.0000)	(.0000)	(.0000)	–	
LnGLB	0.0878	−0.1274**	−0.1553**	0.0327	0.3296***	1
p-value	(.1568)	(.0397)	(.0119)	(.5983)	(.0000)	–

Source: Computed by the authors. Where: ***, **, and * are 1%, 5%, and 10% significant levels, respectively.

unit-root properties of the variables and given the need to account for cross-sectional dependence, the cointegration approach of Westerlund (2007) was applied to test for level relationships for the panel study. The Westerlund (2007) approach has been noted to be more appropriate for establishing level relationships among variables in a panel study of this kind compared to the application of first-generation cointegration techniques as seen in some empirical studies (Ay et al., 2020; Baloch et al., 2021; Hakan et al., 2022; Sharif et al., 2019; Taiwo et al., 2020).

$$\Delta Y_{it} = \delta_i d_t + \phi_i Y_{it-1} + \lambda_i X_{it-1} + \sum\nolimits_{j=1}^{pi} \phi_{ij} \Delta Y_{i,t-j} + \sum\nolimits_{j=0}^{pi} \gamma_{ij} \Delta X_{i,t-j} + \varepsilon_{it} \tag{3}$$

The test for the level of relationship among the variable is in line with the error correction process of the expression in Equation (3). The vector for the parameters is denoted by $\delta_t = (\delta_{i1}, \delta_{i2})'$, and the deterministic terms are captured by $d_t = (1, t)'$, where ϕ stands for the error correction term accordingly. The least-square estimations of the parameter ϕ_i subsequently generate two main statistics for establishing the cointegration relationship among variables namely the panel statistics and the group mean statistics.

3.3 | QR procedure

This study adopted the QR technique as developed by Koenker (1978) and advanced by (Koenker, 2004; Powell, 2016) for the panel coefficient estimation. This approach offers important benefits for the current study when the results from the preceding sections are taken into cognizance, especially concerning the necessity of accounting for possible economic heterogeneity among countries in the panel study. Aside from the capability of the QR approach in producing unbiased results by taking care of potential outliers and possible CD issues (Alola et al., 2021; Magazzino et al., 2021), the approach also makes it possible to observe the impacts of the energy indicators in the panel countries at different quantiles with respect to the dependent variable (carbon emission) which is conditionally distributed (Dogan et al., 2020; Koenker, 2004; Koenker & Hallock, 2001; Nwaka et al., 2020). Therefore, the approach provides a deeper insight into the significance of the explanatory variables to the environmental quality of the region at large. Equation (4) captures the interaction among the variables where the τ^{th} conditional quantile of the explained variable is given as $QLnY_{it}(\tau/\chi_{it})$ while ϕ represents the slope parameter for the explanatory variables at specified quantiles (τ).

$$QLnCO_{2it}(\tau/\chi_{it}) = \phi_i^{(\tau)} + \phi_1^{(\tau)} LnRY_{it} + \phi_2^{(\tau)} LnRY_{it}^2 + \phi_3^{(\tau)} LnNUR_{it} + \phi_4^{(\tau)} LnEGC_{it} + \phi_5^{(\tau)} LnGLB_{it} + \epsilon_{it} \quad (4)$$

Also, in Equation (4), given the individual country *i* in the panel study at specified time *t*, the vector of the regressors for the quantile (τ) is represented by χ_{it} while the error term for the vector is denoted by ϵ_{it}. Going by extant studies it is expected that the estimated slope parameters ϕ_1 and ϕ_2 comes out with significant positive values and negative values to affirm the Environmental Kuznets Curve (EKC) hypothesis for the region (Onifade et al., 2021; Ozturk & Al-Mulali, 2015; Sarkodie & Ozturk, 2020). Finally, although the QR approach is the center focus of the empirical discussion given its inherent qualities that make it suitable for the current study, however, we also reported the estimates from the Dynamic Ordinary Least Squares (DOLS), and the Fully Modified Ordinary Least Squares (FMOLS) approach of Pedroni (2000, 2004) to provide a sensitivity check for the obtained coefficients from the QR before proceeding to explore the Granger causality nexus among the variables.

3.4 | Panel Granger causality

Following the long-run estimates, the panel Dumitrescu & Hurlin, 2012 Granger causality test was utilized in the study to examine the causality nexus among the understudied variables. Given individual panel variable Y_{it} and X_{it}, the causality test follows the expression in Equation (5) where β_{2ik} and β_{1ik} represent the coefficients of the regression and the autoregressive parameters for the individual panel variable respectively.

$$Y_{it} = \delta_i + \sum_{k=1}^{p} \beta_{1ik} Y_{i,t-k} + \sum_{k=1}^{p} \beta_{2ik} X_{i,t-k} + \varepsilon_{it} \quad (5)$$

In Equation (5), the null hypothesis of the absence of causality among variables would be examined against the alternative hypothesis of heterogeneous causality among variables in the framework of a balance panel observation for the understudied variables. Causality analysis in empirical studies of this kind has been widely reported in extant studies (Baloch et al., 2021; Çevik et al., 2020; Çoban et al., 2020; Godil et al., 2021; Khatir et al., 2022). The result of the analysis is detailed in the discussion section.

4 | RESULTS AND DISCUSSION

In this section, we outline the results for the series of preliminary procedures and the result of the impact of the main variables on environmental quality as well as the Granger causality implications.

4.1 | Preliminary results

We begin the discussion of the results by presenting the outputs of the conducted CD test in Table 3. According to the results, there is sufficient evidence to reject the null hypothesis of the absence of cross-section dependence. As such, it was concluded that the residuals are cross-sectionally correlated. Hence, we check the unit-root properties of the variables, and the outcomes are detailed in Table 4.

The unit-root results confirm that the panel variables are not stationary at a conventional significance level of 5%. However, all the understudied panel variables can be described as I(1) at a 5% significance level. As such, bearing in mind the results of the CD test, the subsequent outputs of the applied Westerlund (2007) cointegration test were summarized in Table 5.

The estimates of the cointegration test in Table 5 provide evidence in support of the level of relationship among the understudied panel variables. This further provides a basis to explore the long-run coefficients through the adopted methodologies. Hence, we reported the estimates of the QR approach alongside the outputs from the fully modified ordinary least square (FMOLS) method in Table 7.

4.2 | Results of long-run estimates

From the estimated long-run coefficients in Table 6, the QR technique reveals that natural resource rent worsens environmental quality as it stimulates carbon emission levels among the MENA countries as the coefficients came out positive across all quantiles ($\tau = 0.10$ to $\tau = 0.90$). However, the exasperating impacts of natural resources rent on carbon emission among the countries were not significant at the initial stage as the estimated coefficients came out to be highly significant only at higher quantiles. In essence, it can further be implied that the environmental

TABLE 3 Cross-sectional dependency (CD) test results.

Model	Pesaran (2007) CD test	Pesaran (2015) LM test	Breusch and Pagan (1980) LM test
$LnCO_2 = f\,(LnRY, LnRY^2, LnNUR, LnEGC, LnGLB)$	15.65***	48.80***	459.12***
p-value	(.0000)	(.0000)	(.0000)

Source: Authors' computation. Where: ***, **, and * are 1%, 5%, and 10% significant levels, respectively.

TABLE 4 Panel IPS and CIPS unit root test.

Variables	CIPS		IPS	
	Level	First difference	Level	First difference
	C&T	C&T	C&T	C&T
$LnCO_2$	−2.307	−5.657 ***	−1.7877	−9.4494 ***
$LnRY$	−2.457	−4.687***	−2.3599	−5.1886 ***
$LnRY^2$	−2.834*	−4.807***	−2.1500	−8.0811***
$LnNUR$	−2.657	−4.924***	−2.3294	−3.6461***
$LnEGC$	−1.991	−4.764***	−1.1557	−8.8927 ***
$LnGLB$	−2.883*	−5.156***	−1.8915	−8.1664***

Source: Authors' computation.
Note: The conducted test follows a model that allows for both trends and intercepts. Where: ***, **, and * are 1%, 5%, and 10% significant levels, respectively.

deterioration at the initial stage was mild when considering the distribution of emission levels with respect to resource exploitation and utilization at the initial stage. However, the magnitude of the impacts of natural resources deepens with the higher distribution of carbon pollution. The QR findings were corroborated by the DOLS and FMOLS techniques as the impacts of natural resources rents on carbon emission levels also came out positive and significant from these approaches. Although the later approaches lend credence to the QR estimates in terms of the nature of the relationship between resource rent and carbon emission, they, however, do not show the distribution of this impact. This finding aligns with some extant studies regarding the undesirable aspect of resource rent on environmental quality (Ahmed et al., 2020; Ibrahim & Alola, 2020; Khan et al., 2020; Tufail et al., 2021).

On the aspect of energy consumption in the country, the QR estimates came out with a mix but little evidence in support of any significant impacts on carbon emission level especially at lower quantiles ($\tau = 0.10$ to $\tau = 0.30$) and at intermediate quantiles ($\tau = 0.40$ to $\tau = 0.60$). However, there was consistent and sufficient evidence that energy consumption significantly worsens the environmental quality of the countries at the later stage at upper quantiles ($\tau = 0.70$ to $\tau = 0.90$). The MENA countries are known for their abundant natural resources, especially in the area of oil and gas deposits and the cheap access to this resource has stimulated massive dependence on fossil energy consumption which of course accounts for the largest chunk of the total primary energy consumption in the region. Unconventional energy use has rapidly grown in the MENA region over the years. While the damaging environmental impacts of energy use were not visible at the lower stage distribution of emissions levels, it becomes evident at the latter stage of the distribution. Hence, as energy demand continues to grow with primary energy use being dominated by fossil resources, the region is in jeopardy of more carbon pollution. For instance, fossil resources account for about 100% of total electricity production in places like Libya, and the proportion of electricity production from fossil sources is more than 98% in most of the countries in the region (WDI, 2020). As such, authorities are encouraged to make more effort to stimulate green and sustainable energy production and consumption. This study provides further evidence in support of the conclusions from some studies concerning the deteriorating impact of growing conventional energy consumption on environmental quality in different countries (Ali et al., 2021; Kirikkaleli & Adebayo, 2021; Magazzino & Cerulli, 2019; Umar et al., 2021). The mean estimates from both the DOLS and FMOLS methods also align with findings from the QR. However, these findings are divergent from the results of Ozcan et al. (2020) which show that countries' energy consumption and growth paths can help to improve environmental quality. This conclusion is understandable since the MENA region is not as economically advanced as the OECD countries that Ozcan et al. (2020) studied. In the case of OECD countries, their energy consumption patterns may have begun aligning with environmental policy targets, unlike the MENA states where fossil energy consumption still dominates the huge chunk of total energy portfolios.

Globalization in the MENA region depicted varying degrees of impact on the level of environmental hazard vis-à-vis CO_2 emission in the region. Increasing globalization significantly degrade the environmental quality only at the initial stage but was discovered to be strongly abating emission levels from the tail end of the intermediate quantiles, and this pollution abatement was consistent all the way to the upper quantiles. As such, the undesirable impacts of globalization on CO_2 emission as shown in the mean estimates of the DOLS and FMOLS methods are not supported at the later quantiles. The findings regarding the observed consistent change in the environmental worsening impacts

TABLE 5 Westerlund (2007) cointegration test.

Statistics	Value	Robust *p*-value
Gτ	−1.695***	(.000)
Gα	−2.458	(.500)
Pτ	−5.049***	(.000)
Pα	−2.642***	(.000)

Source: Authors' computation.
Note: The superscript ***, **, and * denote 1%, 5%, and 10% significant levels, respectively.

TABLE 6 QR, DOLS, and FMOLS estimates.

Techniques	Quantile regression (QR)									DOLS	FMOLS
Dependent (var): $LnCO_2$	$\tau = 0.10$	$\tau = 0.20$	$\tau = 0.30$	$\tau = 0.40$	$\tau = 0.50$	$\tau = 0.60$	$\tau = 0.70$	$\tau = 0.80$	$\tau = 0.90$		
LnRY	−0.1844	1.0505	1.7277***	1.5747***	1.9793***	2.0478***	1.1257***	0.7637***	0.8404***	0.2409	1.2488***
p-value	(.9618)	(.1765)	(.0005)	(.0009)	(.0010)	(.0000)	(.0010)	(.0044)	(.0037)	(.3914)	(.0002)
$LnRY^2$	−0.0381	−0.1754	−0.2973***	−0.2665***	−0.3500***	−0.4056***	−0.2944***	−0.2330***	−0.2477***	−0.1181**	−0.2665***
p-value	(.9580)	(.1158)	(.0001)	(.0001)	(.0000)	(.0000)	(.0000)	(.0000)	(.0000)	(.0337)	(.0002)
LnNUR	0.0617	0.0491	0.0275	0.0153	0.0223	0.1569	0.4334***	0.4836***	0.3457*	0.1577**	0.1169***
p-value	(.8822)	(.7510)	(.8010)	(.8826)	(.8029)	(.1906)	(.0000)	(.0000)	(.0642)	(.0129)	(.0230)
LnEGC	0.2473	−0.2327*	−0.1843*	−0.1195	−0.0120	0.1609	0.2682***	0.2602***	0.3481***	0.4357***	0.1304***
p-value	(.1980)	(.0643)	(.0766)	(.2728)	(.9181)	(.2559)	(.0055)	(.0023)	(.0022)	(.000)	(.000)
LnGLB	2.5510***	2.0857**	1.3645**	1.0697	0.3248	−1.0445**	−1.4214***	−1.4458***	−1.4254***	0.6167***	0.1417***
p-value	(.0000)	(.0182)	(.0357)	(.1106)	(.6908)	(.0242)	(.0000)	(.0000)	(.0000)	(.0046)	(.000)
Observation	261	261	261	261	261	261	261	261	261		
No. Regressors	5	5	5	5	5	5	5	5	5		
No. Group	9	9	9	9	9	9	9	9	9		

Source: Author's computation given all variables in natural logarithms. The subscripts *, **, and *** denote the level of statistical significance of estimates at 10%, 5%, and 1% significance levels accordingly.

TABLE 7 DH panel causality test.

Variables	Zbar-stat $LnCO_2$	LnRY	LnNUR	LnEGC	LnGLB	Causality Paths
$LnCO_2$	_	8.9337***	1.03574	4.1870***	1.4444	*LnCO2 → LnRY, LnEGC*
p-value		(.0000)	(.3003)	(.0005)	(.1486)	
LnRY	1.57111	_	0.3033	3.3862***	3.5252***	*LnRY → LnEGC, LnGLB*
p-value	(.1162)		(.7616)	(.0007)	(.0004)	
LnNUR	3.7024***	−1.1759	_	2.9240**	0.6336	*LnNUR → LnCO2, LnEGC*
p-value	(.0002)	(.2396)		(.0035)	(.5263)	
LnEGC	4.7261***	9.7301***	2.5341**	_	1.7204*	*LnEGC → LnCO2, LnRY, LnNUR*
p-value	(.0000)	(.0000)	(.0113)		(.0854)	
LnGLB	7.1256***	9.0188***	0.2945	11.5545***	_	*LnGLB → LnCO2, LnRY, LnEGC*
p-value	(.0000)	(.0000)	(.7683)	(.0000)		

Source: Author's computation.
Note: ***, **, and * are 1%, 5%, and 10% significance levels respectively, while → denotes causality paths. Interpretations were provided at a conventional 5% level of significance.

of globalization from the intermediate quantiles all the way to the upper quantiles could be connected to a couple of issues. Firstly, the globalization index that was used is a composite of various indicators ranging from economic factors to social factors, and also including political and interpersonal factors. As such, related transitions in these indicators are most likely to influence the outcome of the observed impact of globalization on the environmental quality of the region. For instance, awareness of environmental protection is expected to improve more with both social and political transition vis-à-vis the activities of more environmental organizations over the years and most especially in recent times (Liu et al., 2020). Also, globalization may promote environmentally friendly innovations through technology transfer into the region as many of the MENA countries have a high presence of expatriates that are handling various large-scale projects some of which may be incorporating environmental concerns in recent times.

Finally, the estimates from the QR techniques validated the EKC hypothesis for the panel countries within all the quantiles subdivisions (the lower, intermediate, and upper) as the estimated impacts of the real income and its squared values come out with significant positive values and negative values respectively. The implication is that rising income levels are a significant pollutant-enhancing force in the MENA region. The nexus can be better understood when taking a look at the causality results (in Table 7) between income levels and the level of energy consumption in the region which of course is predominantly fossil fuels dependent. The validation of the EKC hypothesis contradicts the findings of Gorus and Aslan (2019) in an aggregated case of the MENA region but supports the findings from Charfeddine and Mrabet (2017) that EKC is valid for oil exporting countries in the region which is the case in this present study. When juxtaposing the findings with the mean estimate approaches, the conclusion regarding the validity of the EKC is strongly upheld by the mean estimates of the FMOLS. As for the DOLS outputs, while the estimated coefficient follows the right signs for the validity of the EKC, there was little or insufficient evidence to justify the hypothesis given that the impacts of the initial income level were insignificant even though the coefficient itself was positive in the model. Finally, the diagnostic checks of the quantile slope equality test in Table A1 in the appendix reveal that estimated slope parameters vary significantly across the examined quantile levels.

4.3 | Results of Granger causality estimates

The causality evidence in Table 7 shows that the trio of natural resource rent, energy consumption, and globalization significantly caused carbon emission levels in the MENA region. The income dynamics is much of an indirect flow.

Income levels among the countries are a major driver of the levels of energy consumption as there was a strong bi-directional causality between both variables. On the other hand, the energy consumption Granger causes the level of carbon emission in the region while there was no direct causality between income levels and pollutant emissions. These results buttressed the long-run estimates as it reveals that growing income levels are a major stimulant of energy consumption in the MENA region which in turn hampers the environmental quality of the region as the largest chunk of the energy consumption is fossil fuel-based. Also, there is a strong one-way causality from CO_2 emission to income levels. This causality output does stands as a timely indicator to the authorities of the MENA states that adequate caution must be exercised in implementing carbon mitigation policies so as not to create more economic woes since a strong causality link can be observed between emission levels and income levels.

5 | CONCLUSIONS AND POLICY SUGGESTIONS

The study conducts an assessment of the impacts of natural resources rent and energy consumption on the quality of the environment in selected MENA countries in addressing pertinent issues bordering on environmental sustainability. To achieve the study's aim and objectives the QR technique was utilized to empirically analyze the samples that were drawn for the countries between 1990 and 2018. The study also explored the mean estimates from the combination of the FMOLS and DOLS approaches for a wider analysis and robustness checks. The empirical analysis reveals that both natural resources rent and income levels significantly hamper the environmental quality of the region. The latter especially worsens the environmental quality as it is a driver of the main fossil fuel-dependent energy consumption which in turn worsens the quality of the environment through growing CO_2 emission levels. On the other hand, while natural resource rent hampers environmental sustainability in the MENA region, the exacerbating impacts of globalization on environmental pollution via CO_2 emission dampen at the intermediate and upper quantiles thereby enhancing the environmental sustainability of the region at a later stage. The possible explanation for the dimensional change in the impacts of globalization on the environmental quality of the region was tied to the related transitions in the indicators for the applied globalization index. For instance, the level of awareness about environmental protection is expected to improve more over time with both social and political transitions. The study also upholds the EKC hypothesis for the MENA region.

5.1 | Policy suggestion

The empirical results indicate the need for the authority in the MENA region to channel the resources advantages and growing income benefits to clean energy investments. This would be a vital step towards reducing rates of emission while enhancing a better path for the regional ecological footprint. This is not an impossible task. Going by the long-run estimates and the causality evidence, the MENA region can take advantage of globalization in achieving green policy agenda for the region through technological transfer that can induce renewable energy consumption and most especially from the perspective of boosting renewable electricity generation. A diversification of the energy mix from the focus on fossil energy use to renewables would be a good step in the right direction for the region. There is a huge renewable sources potential for the region, especially in the area of solar and wind energy (Aghahosseini et al., 2020). As such, we recommend adequate political will to sponsor large-scale green projects to tape the wealth of renewable sources in the region, especially wind and solar. Some countries in the region have gradually started acting but more still needs to be done. For instance, the huge potential in some viable renewable energy projects like Concentrated Solar Power (CSP) as seen in the UAE can also be replicated among other countries in the MENA region (Sisodia et al., 2020). The countries can also take advantage of the public-private financial scheme in supporting renewable and sustainable energy projects.

Also, globalization may promote environmentally friendly innovations through technology transfer into the region as many of the MENA countries have a high presence of expatriates that are handling various large-scale projects. Thus, it is further recommended that the authority of the region should make the incorporation of environmental concerns a mandatory aspect of project executions, especially when dealing with large-scale constructions and general urban planning. In addition, the MENA region needs to be more actively involved in partnering with international agencies on environmental protection by supporting environmental quality protection initiatives via necessary support for green energy projects given the abundant resource.

It is worth noting that any carbon emission combating approach that must be taken in the region must ultimately factor in any possible negative impact of such policy on income levels as there is a strong one-way causality from CO_2 emission to income levels. As such, we recommend a strong commitment toward a steady but gradual shift from conventional energy consumption in the region.

6 | LIMITATIONS OF STUDY AND FUTURE RESEARCH

The exclusion of some MENA countries from the current analysis was prompted by either non-availability of data or data aggregation. In addition, although the present study has mainly focused on the natural resource aspect of the environmental discussion for MENA states, the review of the vast literature that was conducted has revealed several factors that can affect environmental quality levels. Therefore, future studies can expand the current framework to accommodate more factors, and the studies can also explore the possibility of conducting an alternative non-linear model estimation to extend the ongoing discussion for the MENA region or other regions across the globe.

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DATA AVAILABILITY STATEMENT

The data source has been reported in the manuscript

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APPENDIX A

TABLE A1 Slope equality test.

	0.1 vs. 0.2	0.2 vs. 0.3	0.3 vs. 0.4	0.4 vs. 0.5	0.5 vs. 0.6	0.6 vs. 0.7	0.7 vs. 0.8	0.8 vs. 0.9
LnRY	−1.2350	−0.6771	0.1529	−0.4045	−0.0685	0.9220***	0.4219***	−0.0767
$LnRY^2$	0.1373	0.1219	−0.0307	0.0834**	0.0556	−0.1112***	−0.0715***	0.0146
LnNUR	0.0125	0.0216	0.0121	−0.0069	−0.1345**	−0.2765***	−0.0527	0.1378
LnEGC	0.4800***	−0.0483	−0.0648	−0.1074	−0.1729**	−0.1072	0.0075	−0.0878
LnGLB	0.4652	0.7212	0.2948	0.7449	1.3693***	0.3769	−0.0444	−0.0204
Wald Test (Chi-Sq. Stat)		328.7498						
p-value		.0000						

Source: Authors' computation.
Note: The superscript ***, **, and * denote 1%, 5%, and 10% significant levels, respectively.