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A Panel Threshold Analysis of the Impact of Renewable and Non-Renewable Energy Consumption on Economic Growth in Selected MENA Countries

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ABSTRACT

The study investigates the impact of renewable and non-renewable energy consumption on economic growth in the Middle East and North Africa from 1996 to 2023. The research uses the threshold model methodology to determine the relationship between energy consumption and economic growth, based on GDP, non-renewable energy consumption, and renewable energy consumption. The findings show that the influence of the new energy transition threshold on economic growth depends on the levels of gross domestic product, renewable energy consumption, and fossil fuel energy consumption. The study concludes that the impact of renewable and non-renewable energy consumption on economic growth is non-linear, varying with levels of these factors. The evidence suggests that the behaviours of renewable and nonrenewable energies are similar, which may indicate that the economy is at a single structural level and that structural transformation has not been sufficiently robust. The interaction between renewable and non-renewable energy and economic growth is not restricted to a specific threshold, as each threshold level represents different dimensions of the economic dynamics of the countries. In brief, Heavy reliance on traditional energy sources will result in significant economic resistance, which will negatively impact economic growth. However, with improved renewable energy infrastructure and reduced reliance on traditional or non-renewable energy, this negative impact will transform into a positive effect on long-term economic growth.

Keywords: Renewable Energy Consumption, Non-renewable Energy Consumption, Economic Growth, Panel Threshold Model
JEL Classifications: O24, Q4, Q5

1. INTRODUCTION

In recent decades, the relationship between energy consumption and economic growth has attracted the attention of many researchers, who have attempted to explain it in their studies due to its significant impact on sustainable development policies in various countries. This trend is particularly true given the earnest efforts of countries to reconcile two essential challenges: achieving sustainable economic growth and fulfilling their climate commitments under the Paris Agreement of 2016 (Azam et al., 2021; Ivanovski et al., 2021). Additionally, recent comprehensive analyses across diverse economies demonstrate that this relationship varies significantly based on the type of energy consumed, with renewable energy sources consistently exhibiting better long-term economic outcomes compared to fossil fuels. Rahman et al. (2024) provide compelling evidence from emerging

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economies that strategic energy finance policies can enhance the positive impact of energy consumption on economic growth, particularly when coupled with effective governance structures. With the intensification of global efforts to achieve sustainability, the importance of balancing these two energy sources (renewable and nonrenewable energy) increases. In the same manner, the study by Sarsar and Echaoui (2024), applying to 124 countries, indicated that transformations in the energy sector, especially in the context of economic complexity, can significantly enhance economic growth, particularly in developing countries. This suggests that building productive and cognitive capacities is crucial for the economy to benefit more from the energy transition, particularly in less developed economies where the effects of complexity are stronger. Wang et al. (2024) showed that the relationship between renewable energy, economic growth, and carbon emissions exhibits complex and nonlinear patterns across different countries, necessitating the reliance on advanced methods to analyze this relationship, such as threshold models and nonlinear models, to interpret and understand it accurately. The current transformation in the energy sector that the world is witnessing has brought about radical changes in the dynamics of energy-growth relationships, as renewable energy technologies have demonstrated significantly better economic characteristics compared to traditional fossil fuel sources. The importance of distinguishing between renewable and non-renewable energy sources in growth analysis is further highlighted by Wang et al. (2024), who demonstrate that the environmental Kuznets curve relationship varies significantly depending on the energy mix, with renewable energy helping to decouple economic growth from environmental degradation. These global insights have particular relevance for regions undergoing rapid economic development while facing mounting pressure to transition toward cleaner energy systems.

The Middle East and North Africa region (MENA countries) emerges as a uniquely important case study for investigating renewable and non-renewable energy-growth relationships due to several distinctive characteristics that make it particularly suitable for rigorous empirical analysis. The region's strategic importance in global energy markets cannot be overstated, as it controls approximately 48-58% of the world's proven oil reserves and over 43% of natural gas reserves (Resource Governance, 2025), making energy policy decisions in MENA countries consequential for global economic stability. This dominant position in fossil fuel markets creates unique economic dynamics where energy transition policies must balance domestic development objectives with economic dependence on oil export revenues, a challenge that distinguishes MENA from other developing regions (Resource Governance, 2025). Recent analyses by the International Renewable Energy Agency (IRENA) indicate that the region could obtain almost 26% of its total primary energy supply from renewables by 2050, with the renewable share reaching 53% in the power sector, potentially resulting in emissions reduction equivalent to 1.1 Gt CO_2 annually (IRENA, 2024). However, current renewable energy deployment remains critically low, with renewables accounting for only 0.4% of the total primary energy mix (Ragab and Mahmoud, 2025), highlighting the massive transformation required to achieve these targets.

The economic diversity within MENA countries provides an ideal natural experiment for comparative analysis of energy-growth relationships. The region encompasses both major energy exporters (Algeria, Iran, Saudi Arabia, UAE) and net energy importers (Jordan, Morocco, Tunisia), creating variation in resource endowments that enables robust comparative analysis while controlling for regional factors such as climate, culture, and geopolitical influences (Bouoiyour and Selmi, 2013). Moreover, MENA countries exhibit varying levels of economic development and structural characteristics, from high-income oil exporters to middle-income diversified economies, providing insights into how the energy-growth nexus operates across different development contexts (Elbadawi and Gelb, 2010; Mahmood et al., 2023).

This study aims to provide a precise and comprehensive analysis of the relationship between energy consumption and economic growth in the Middle East and North Africa, with a clear distinction between the effects of renewable and non-renewable energy. The study focuses on filling existing research gaps, particularly regarding the impact of various economic and institutional conditions in the region, using advanced data analysis methodologies that account for cross-dependence and structural changes. Through this, the study aims to provide evidence-based insights to support the formulation of energy policies that effectively contribute to achieving sustainable economic growth and environmental balance in the region. To achieve that purpose, the study is divided into several sections: the introduction, research methodology and data used, results and discussion, and finally the conclusion.

2. LITERATURE REVIEW

In this part of the paper, the literature review is divided into two main parts. First, it includes previous studies that examine the impact of renewable energy consumption on economic growth. Secondly, it focuses on previous studies that examine the impact of non-renewable energy consumption on economic growth.

2.1. Renewable Energy and Economic Growth

Recently, the importance of enhancing energy security has emerged due to increasing concerns about the depletion of traditional energy sources, in addition to the negative impacts of greenhouse gas emissions and the accompanying environmental issues (Koçak and Şarkgüneşi, 2017). Therefore, it has become necessary to transition to the use of renewable energy sources as a safe and sustainable alternative. Therefore, it is essential to understand the relationship between renewable energy consumption and economic growth by revealing the economy's dependence on energy and designing energy policies (Yildirim and Aslan, 2012). In this context, the literature explores four common hypotheses that illustrate the nature and direction of the relationship between energy consumption and economic growth: Omri (2013), Durrani et al. (2022), Jia et al. (2023), and Biala et al. (2025).

There are four main hypotheses that make up the theoretical framework for energy-growth relationships. These hypotheses have guided empirical research in different parts of the world. The growth hypothesis asserts that energy consumption is essential for economic development, indicating that energy limitations may hinder economic advancement. The conservation hypothesis asserts that economic growth increases energy demand, indicating that policies encouraging energy conservation may not adversely affect the economy. The feedback hypothesis posits a reciprocal relationship between energy consumption and economic growth, whereas the neutrality hypothesis asserts the absence of a significant causal connection between these variables (Salehin and Kiss, 2022; Biala et al., 2025).

Based on these hypotheses, the results related to energy-linked economic growth varied between countries, and no consensus was reached in the literature (Bhattacharya et al., 2016). Differences were observed in the studies in terms of the countries examined, the times, the types of energy, the standard economic methods, and the results (Ozturk, 2010; Koçak and Şarkgüneşi, 2017). For example, Apergis and Payne (2010; 2011; 2012) obtained results that demonstrate the feedback analysis between renewable energy and economic growth through the usage of panel co-integration, panel dynamic least squares (DOLS), fully modified least squares (FMOLS), and panel vector error correction (VEC) methodologies across 20 OECD countries, 6 Central American nations, and 80 randomly selected countries. Using panel data analysis, Salim and Rafiq (2012) examined six major emerging economies from 1980 to 2006; Al-mulali et al. (2014) studied eighteen Latin American countries from 1980 to 2010; and Shahbaz et al. (2016) analyzed BRICS countries from the first quarter of 1991 to the fourth quarter of 2015, all identifying a bidirectional relationship between renewable energy consumption and economic growth. Pao and Fu (2013) investigated the association between renewable energy usage and economic growth in Brazil from 1980 to 2010 utilizing time series analysis. The study obtained data that corroborates the feedback hypothesis. Lin and Moubarak's (2014) study for China, and Shahbaz et al. (2015) study for Pakistan yielded analogous results. Similarly, Azam et al. (2021) explored the impact of renewable electricity consumption on economic growth for a group of 10 newly industrialized countries from 1990 to 2015. The study employed various methods such as unit root tests, the heterogeneous cointegration method, the fully modified ordinary least squares method, and the Granger causality method. The results of the Granger causality test indicated a bidirectional causal relationship between renewable electricity consumption and economic growth in both the short and long term, supporting the feedback hypothesis. This means that the feedback hypothesis is valid for newly industrialized countries.

Payne (2009) obtained results that corroborate the neutrality hypothesis over the period 1946-2006 in the USA, using the Toda-Yamamoto causality approach. Ocal and Aslan (2013) and Dogan (2015) obtained analogous data for Turkey. In a panel data analysis that consisted of 27 European countries, Menegaki (2011) was unable to identify a significant correlation between economic growth and renewable energy, indicating support for the neutrality hypothesis.

Bilgili (2015) analyzed the correlation between renewable energy and industrial production in the USA from 1981 to 2013 using monthly data and the wavelet coherence technique and obtained results that corroborated the growth hypothesis. Bilgili and Ozturk (2015), along with Ozturk and Bilgili (2015), found that renewable energy positively influenced economic growth in G7 nations and 51 sub-Saharan African countries from 1980 to 2009, using panel co-integration, panel OLS, and panel DOLS methodologies. Inglesi-Lotz (2016) for 34 OECD nations and Hamit-Haggar (2016) for 11 sub-Saharan African countries obtained statistics that corroborate the growth hypothesis. Bhattacharya et al. (2016) examined the period from 1991 to 2012 across 38 leading renewable energy-consuming nations, accounting for linear cross-sectional dependence and heterogeneity, and determining that renewable energy consumption positively influences economic growth in 57% of the countries studied. Aghayeva and Zortuk (2024) explored the impact of renewable and non-renewable energy consumption on economic growth in Azerbaijan, employing Augmented ARDL, FMOLS, and DOLS models. The results concluded that an increase in renewable energy consumption by 1% leads to an increase in economic growth by 1.29% in Azerbaijan.

Tiwari (2011) obtained data that corroborates the conservation hypothesis for India for the period from 1960 to 2009, employing the Structural Vector Autoregressive (VAR) model methodology. Al-Mulali et al. (2013) analyzed the relationship between renewable energy use and economic growth across different eras in high-, upper-, lower-, and low-income nations, categorizing them into four groups via the FMOLS approach. He obtained results that corroborate the conservation hypothesis in 2% of the countries, the neutrality hypothesis in 19% of the countries, and the feedback hypothesis in the remaining 79%. Similarly, Alper and Oguz (2016) obtained mixed results for the period from 1990 to 2009 for new EU member countries, employing an asymmetrical causality test methodology alongside the autoregressive distributed lag (ARDL) technique. Experimental results support that the consumption of renewable energy has positive effects on economic growth for all the countries studied. However, only Bulgaria, Estonia, Poland, and Slovenia showed a statistically significant impact on economic growth. Cyprus, Estonia, Hungary, Poland, and Slovenia support the neutrality hypothesis, while the Czech Republic supports the conservation hypothesis. The hypothesis indicates a causal relationship between economic growth and renewable energy consumption, as well as between energy consumption and economic growth in Bulgaria. Koçak and Şarkgüneşi (2017) presented varying results regarding the interpretation of the relationship between renewable energy consumption and economic growth in the Balkans and Black Sea countries during the period from 1990 to 2012. The study concluded that there is a long-term equilibrium relationship between renewable energy consumption and economic growth, and that its consumption has a positive impact on economic growth. The results of the heterogeneous causality analysis support the growth hypothesis in Bulgaria, Greece, Macedonia, Russia, and Ukraine; the feedback hypothesis in Albania, Georgia, and Romania; and the neutrality hypothesis in Turkey. According to the panel data set that includes all nine countries, the results support the feedback hypothesis. Based on these results, the study concluded that there is a significant impact of renewable energy consumption on economic growth in the Balkan and Black Sea countries. Based on the above, experimental research has demonstrated inconsistent results about the relationship between renewable energy consumption and economic growth. Consequently, we can formulate the next hypothesis:

H_1: There is a linkage between renewable energy consumption and economic growth in MENA countries.

2.2. Non-Renewable Energy and Economic Growth

There is conflicting evidence regarding the nature of the relationship between non-renewable energy consumption and economic growth. Many studies indicate that the consumption of fossil fuel energy is essential for economic growth; therefore, a decrease in energy consumption may harm economic growth. For example, Mohammadi and Barfarish (2014) examined the relationship between non-renewable energy consumption and economic growth in 14 oil-exporting countries between 1980 and 2007. They found that energy consumption causes output growth in the long term. Using the nonlinear ARDL bounds testing approach, Shahbaz et al. (2017) examined the asymmetric relationship between energy consumption and economic growth in India. They found that only negative shocks to energy consumption adversely affect economic growth. In a related manner, Awodumi and Adewuyi (2020) also used the nonlinear ARDL technique to investigate the impact of non-renewable energy on economic growth in the five largest oil-producing African countries (Algeria, Angola, Egypt, Gabon, and Nigeria) from 1980 to 2015. They found an asymmetric impact of per capita energy consumption (oil and natural gas) on output growth in each of the sample countries except for Algeria.

Nonetheless, other investigations have arrived at divergent outcomes. Salamaliki and Venetis (2013) employ various horizons and sequential causality testing methods to investigate the impact of non-renewable energy sources on economic growth in G7 nations. They conclude that non-renewable energy consumption does not influence actual GDP. Rafindadi and Ozturk (2015) examine the influence of natural gas usage on economic growth in Malaysia from 1971 to 2012, using Johansen co-integration and ARDL bounds testing. Their data validate the neutrality hypothesis. There is no causal relationship between natural gas use and economic growth in any direction for Malaysia. Likewise, Wang et al. (2019) identify a disassociation link between economic growth and fuel use in China and India. Similarly, Yildirim et al. (2014) utilize a bootstrapped autoregressive metric causality method to examine the impact of nonrenewable energy consumption on economic growth in a cohort of developing nations. They determine that energy use does not influence economic growth. Conversely, Mensah et al. (2019) identify a bi-directional causal relationship between non-renewable energy usage and economic growth. Similarly, Osman et al. (2016) studied the relationship between electricity consumption and economic growth using annual data from 1975 to 2012 in the Gulf Cooperation Council (GCC) countries, using the PMGE methodology. The results indicated a bidirectional causal relationship between electricity consumption and economic growth in these economies, supporting the feedback hypothesis. Consequently, the evidence implies that if these countries adopt any energy or electricity conservation policies, this could have a negative impact on their economic growth.

Based on the above, experimental research has demonstrated inconsistent results about the relationship between nonrenewable energy consumption and economic growth. Consequently, we can formulate the next hypothesis:

H_2: There is a linkage between nonrenewable energy consumption and economic growth in MENA countries.

3. DATA AND METHODOLOGY

The study depended on the previous research, particularly that related to economic growth theory and energy development models, to define the variables and make adjustments to account for the unique characteristics of the study area to evaluate the potential impacts of both renewable and non-renewable energy consumption on economic growth in Middle Eastern and North African countries. It also provided data for annual time series during the study period. Although these variables differ from one study to another, they were selected with the objective of including them in the model, as shown in Table 1. The study covers 10 countries in the Middle East and North Africa region (including Algeria, Egypt, Iraq, Lebanon, Libya, Morocco, Syria, Tunisia, Yemen, and Turkey). Annual data spans the period from 1996 to 2024. We obtained our data from the World Bank Database.

The study uses the dynamic cross-sectional data model with correction for fixed and time effects. The basic model is as follows:

$$ln(GDP_{it}) = \beta_0 + \beta_1(REC_{it}) + \beta_2(FFEC_{it}) + \beta_3(ANE_{it}) + \beta_4\, ln(GDI_{it}) + \beta_5\, ln(LAB_{it}) + \beta_6\, Co2_{it} + \beta_7\, ln(URB_{it}) + \beta_8\, ln(REGU_{it}) + \mu_i + \lambda_t + \varepsilon_{it}$$

The symbols (i, t) represent the country and year, respectively. (μ_i) represents the country fixed effects. (λ_t) represents the time fixed effects. ($\varepsilon_{i,t}$) represents the random error term.

Our study used the Fixed Effect Panel Threshold Model (FEPTM) to determine whether the relationship between renewable and non-renewable energy and economic growth is nonlinear and dependent on a certain threshold of renewable energy consumption.

Generally, economic models are classified as parametric, non-parametric, and semi-parametric in the econometric literature. Parametric models impose a strict functional form, while non-parametric models do not impose any functional assumptions. Semi-parametric models offer a certain level of flexibility (Hardle et al., 2004). In our current study, we will rely on the fixed-effect threshold model for panel data proposed by Hansen (1999). This framework is a semi-parametric model, as it assumes a parametric linear relationship at each step of the model's implementation. The transition from one step to the next occurs automatically via the threshold effect, thus creating a non-linear effect that varies according to circumstances, while also providing flexibility for adapting to other variables within the model. In this study, we used LGDP as a threshold within the model once, renewable energy variable once, and non-renewable energy once again. This analysis was done to observe the differences in results when using each variable. We are using in our study the single-threshold model

Table 1: Variable measurements

Variables	Symbol	Measurement	Source
Economic Growth	lGDP	GDP (constant 2015 US$)	World Bank Data
Renewable energy consumption	REC	Renewable energy consumption (% of total final energy consumption)	World Bank Data
Fossil fuel energy consumption	FFEC	Fossil fuel energy consumption (% of total)	World Bank Data
Alternative and nuclear energy	ANE	Alternative and nuclear energy (% of total energy use)	World Bank Data
Capital formation	lGDI	Gross fixed capital formation (constant 2015 US$)	World Bank Data
Labor force	lLAB	Labor force, total	World Bank Data
Carbon dioxide (CO_2) emissions (total)	CO2	Million tonnes of carbon dioxide	World Bank Data
institutional quality	REGU	Regulatory Quality (%)	World Bank Data
Urbanization	URB	Urban population (% of total population)	World Bank Data

(Hansen, 1999), with the following considerations:

$$y_{it}it = \propto + X_{it}(q_{it} < \gamma)\beta_1 + X_{it}(q_{it} \geq \gamma)\beta_2 + u_i + e_{it}$$

Where: q_{it} is the threshold variable, and γ is the threshold parameter that divides the equation into two regimes with coefficients β_1 and β_2, The parameter u_i is the individual effect, while e_{it} is the disturbance. it can also write as:

$$y_{it}it = \propto + X_{it}(q_{it}, \gamma)\beta + u_i + e_{it}$$

This formulation implies two regimes:
- First: When $q_{it} \leq \gamma$ the slope coefficient is β_1.
- Second: When $q_{it} > \gamma$ the slope coefficient is β_2.

Thus, the marginal effect of X_{it} on y_{it} depends on whether the threshold variable lies above or below the estimated threshold value.

Estimation Procedure

Step 1. Fixed-effects transformation Individual effects are removed using the within transformation.
Step 2. Grid Search for γ

A grid search over possible values of γ is conducted. For each candidate γ, the model is estimated and the sum of squared residuals (SSR) is computed:

$$SSR(\gamma) = \sum_{\{i=1\}}^{N} \sum_{\{t=1\}}^{T} \hat{\varepsilon}_{it}^2(\gamma)$$

Step 3. Threshold estimate: The threshold estimate $\hat{\gamma}$ is the value of γ that minimizes SSR(γ). Threshold effect test: To test whether the threshold effect is statistically significant (i.e., whether $\beta_1 \neq \beta_2$), Hansen (1999) proposes a bootstrap method because the threshold parameter is not identified under the null hypothesis (no threshold effect).

Null hypothesis: H_0: $\beta_1 = \beta_{2|}$ (No threshold effect)

Alternative: H_1: $\beta_1 \neq \beta_2$ (Threshold exists)

The test statistic is based on the likelihood ratio (LR):

$$LR(\gamma) = \frac{SSR(\gamma) - SSR(\hat{\gamma})}{\hat{\sigma}^2}$$

where: $\sigma^2 = \frac{SSR(\gamma) - SSR(\hat{\gamma})}{NT}$. The distribution of the LR statistic is non-standard, so critical values are obtained through bootstrap resampling.

If a significant threshold is found, the relationship between y_{it} an X_{it} is piecewise linear, with coefficients that shift once the threshold variable crosses the estimated threshold value. The single-threshold model is thus a powerful tool for detecting nonlinear regime shifts in economic relationships, for instance, in energy–growth dynamics, where the effect of renewable energy consumption on growth may depend on whether the economy has crossed a certain development or energy-use threshold.

4. RESULTS AND DISCUSSION

The empirical results from threshold panel regression offer substantial information about the complex relationship between energy consumption, economic growth, and environmental dynamics. In addition to the statistical significance of the estimates, these results highlight nonlinear patterns that reflect the heterogeneity of the countries included in the sample. In particular, the threshold results indicate that the effects of renewable and non-renewable energy consumption and carbon dioxide emissions on economic growth are not constant and depend on the critical levels of consumption at which a country's economy is located. The impact before these levels is not the same as after them. From a theoretical perspective, they extend the traditional growth–energy–environment nexus by showing that marginal effects vary across regimes rather than being constant. From a policy standpoint, the results indicate that energy and climate strategies may only be effective after countries exceed certain thresholds of renewable adoption or energy consumption. This implies that the debate focuses not on whether growth influences energy demand and emissions, but rather on when and under what conditions this influence becomes more pronounced. Accordingly, the following discussion contextualises the econometric results within a larger literature, compares them with earlier empirical evidence, and elaborates on possible structural, institutional, and policy factors that could explain the observed patterns.

In the context of this study, we developed three threshold testing models: the first uses a GDP threshold to see how the impact of renewable and non-renewable energy might differ at a given level or stage of economic growth or development; the second uses a renewable energy consumption threshold to see how the impact of renewable on economic growth varies at a given level of renewable energy consumption due to certain policies, improvements in energy infrastructure, or structural shifts in the energy mix; the third uses a total energy consumption threshold to see how the impact of renewable and non-renewable energy on economic growth might change or vary as a result of shifts in energy consumption or economic activity in general. A single threshold will be tested for each of the three models. The data will be repeatedly sampled 300 times using the bootstrap method to obtain the F and P statistic values as shown in Table 2.

Table 2 indicates that in the panel threshold model, GDP has one threshold value that is statistically significant at the 5% level. The renewable energy consumption also has a single threshold value that is statistically significant at the 10% level. The Fossil fuel energy consumption has only one threshold value, which is statistically significant at the 1% level.

We can estimate the values of the specified thresholds based on the threshold values. Table 3 displays the estimated results. The single-threshold model is divided into two sections: Firstly, when the threshold variable's level falls below the threshold value; secondly, when the threshold variable's level surpasses the threshold value.

The results of the panel threshold model were established by using gross domestic product, renewable energy consumption and nonrenewable energy consumption as threshold variables. The results show that the impact of new energy consumption transformation on economic growth varies across different segments of the different threshold values.

Despite this similarity in the results of all models in terms of sign and significance, we observe that the threshold at which economic growth changes varies with the type of threshold or threshold variable. Therefore, the interaction between renewable and non-renewable energy, on the one hand, and economic growth, on the other, is not restricted to a specific threshold, because each of the three threshold levels represents a different dimension of the economic dynamics of the countries in the study sample. This idea is supported by Wang (2015), Balsalobre-Lorente et al. (2022), Wang et al. (2019), Okui and Yanagi (2020), and Ruckthongsook et al. (2018). To confirm the results Table 4, we estimated the kernel density test to examine the overall distribution of each threshold variable, as shown in the Figure 1.

Figure 1 contains kernel density estimates for three variables: Real GDP (lGDP), non-renewable energy consumption (FFEC), and renewable energy consumption (REC). These graphs assist in the Threshold Effect Test by examining the distribution of each variable and identifying the possibility of regions or levels where the relationship between other variables and economic output changes. These graphs also illustrate a significant diversity and heterogeneity in the distribution of variables, which provides a strong justification for using the threshold effect test. The presence of peaks, or sudden changes in density, indicates the likelihood of a change in the behaviour of the economic relationship at certain

Table 2: Threshold effect test (bootstrap=300)

Threshold variables	F-value	P-value	BS	10%	5%	1%
lGDP	85.93	0.0200	300	60.6073	73.2602	90.7602
REC	42.73	0.0700	300	39.1747	45.8893	74.8958
FFEC	82.25	0.0000	300	40.6813	49.1739	60.7978

Source: Outcomes by Stata 17

Table 3: Threshold estimator (level=95)

Threshold variables	Threshold value	Lower	Upper
GDP	24.8670	24.8321	24.8714
REC	3.1000	3.0000	3.2000
FFEC	99.2400	99.2000	99.3000

Source: outcomes by Stata 17

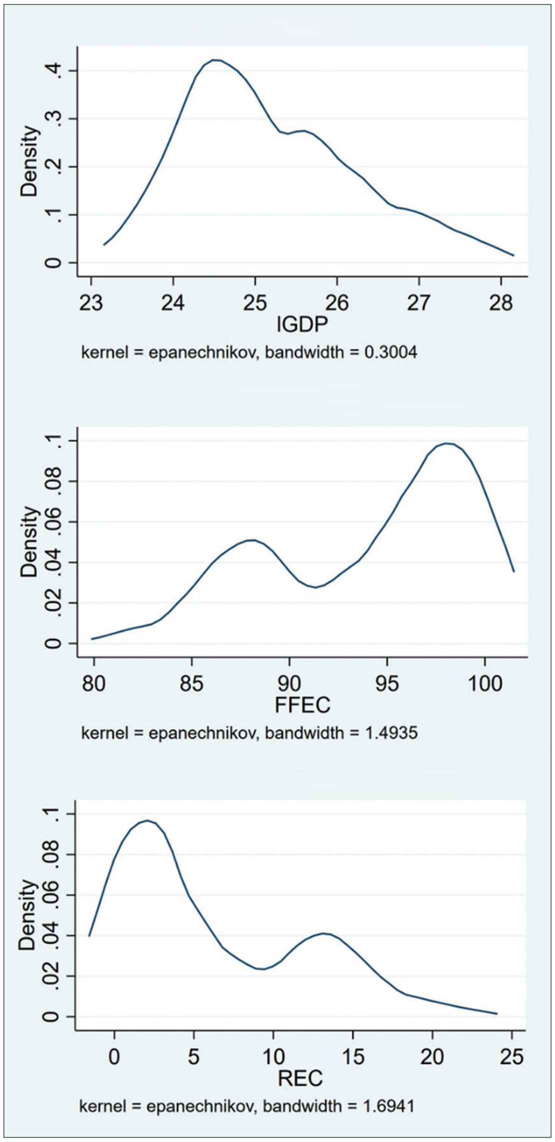
Table 4: Threshold model regression results

LGDP	Threshold model		
	GDP	REC	FFEC
LREC			
0	−0.0619137*	−0.183037***	−0.238022***
1	−0.088431***	−0.1690354*	−0.156876***
LFFEC			
0	3.375456***	2.687342***	2.799198***
1	3.43868***	2.637559***	2.756902***
ANE			
0	0.0906271***	0.2258847***	0.060240***
1	0.0809749***	0.0618041***	−0.4322421
LGDI	0.0633916***	0.093014***	0.1008089***
LLAB	0.8660761***	1.317264***	1.112747***
URB	−0.007277*	−0.008867**	−0.0050196
REGU	0.1801118***	0.20494***	0.1242812***
Cons	−5.11**(0.031)	−9.08**(0.020)	−6.79**(0.024)
Obs	280	280	280
rho	0.97904964	0.98492642	0.97662598
F test (u_i)=0	165.41	95.14	115.33
Prop>F	0.0000	0.0000	0.0000
R^2	0.8914	0.8481	0.8660

Source: outcomes by Stata 17

levels. For example, the sensitivity of GDP to renewable energy may differ if the consumption ratio exceeds a certain threshold. In the context of threshold testing, these graphs are useful in selecting the threshold point and justifying it economically, and they support the assumption of the presence of nonlinearities in the studied economic relationship. The IGDP curve shows that the distribution of GDP is not entirely normal, and there is a concentration around a certain value with a rightward extended tail. This suggests the possibility of threshold levels at which the impact of explanatory variables on the output may change. The FFEC curve shows the distribution of nonrenewable energy consumption with two clear peaks, indicating the possibility of two different thresholds in the sample or groups of countries or times within the data. This may support the idea of testing for a threshold or even the existence of multiple thresholds for the variable. And the REC curve for renewable energy consumption shows that it is less common among most countries in the sample, with a clear concentration near zero, along with some larger values. This result reflects that the majority of countries are still at low levels of reliance on renewable energy, supporting the idea of a threshold effect on the relationship between renewable energy and economic

Figure 1: Kernel density estimate



Source: outcomes by Stata 17

growth. In short, density curves are essential for examining the heterogeneity in the distribution of variables as a first step before conducting the threshold test. The graphs indicate the presence of clusters and potential threshold levels in each variable, which makes the threshold test suitable for analysing the relationship between these variables and economic output in our model.

4.1. Gross Domestic Product Threshold Effect Test

The results, as shown in Table 4, indicate that the threshold value of GDP was 24.8670, within a robust range to take into account the variations between different countries in the study sample. This range is the value falling between the upper value (24.8714) and the lower value (24.8321), using bootstrap = 300. Furthermore, the F-statistic value is greater than the critical values at the 5% significance level. It means that the test is statistically significant at the 5% level. Therefore, it can be concluded that introducing the threshold significantly improves the model and that the nonlinear model remains suitable for describing the relationship under study with the sample divided into different subsystems. Accordingly, when the GDP level is below the threshold value (24.8670), renewable energy consumption has a significant negative impact on economic growth, with the marginal coefficient of impact being −0.0619. When the GDP level is above the threshold value, the negative impact of renewable energy consumption on economic growth increases significantly, with the marginal coefficient of impact being −0.0884. This analysis demonstrates that the level of economic development in developing countries or countries with limited infrastructure is an important factor in determining the economic cost of shifting toward increased renewable energy consumption. This decreased GDP is due to lower investment in renewable energy technology or infrastructure, which requires significant investments due to their high costs. The poor efficiency of renewable energy compared to fossil fuels, for example, in the short term is also a significant factor in this negative relationship. This is because the productive sectors in these countries rely heavily on fossil fuels, and most renewable energy consumption is directed toward household consumption rather than production, thus not directly translating into economic growth. Furthermore, increased reliance on renewable energy in the short term comes at the expense of the efficiency of production, which relies on fossil fuels. Furthermore, for the negative impact of renewable energy to transform into a positive impact, it takes time. Consequently, the positive impact becomes apparent in the long run as a result of increased investment in renewable energy technological infrastructure. This means that when GDP levels are high, countries direct a significant portion of their support toward investment in renewable energy. This finding aligns with studies by (Shahbaz et al., 2020; Xie et al., 2018; Carfora et al., 2019; Rahman et al., 2024; Chen et al., 2020; Raza et al., 2020; Can and Korkmaz, 2019; Sijabat, 2024; Kayani, 2021; Wang et al., 2023; Ocal and Aslan,2013; Fuinhas and Marques, 2012; Feng and Zhao, 2022; Mighri and AlSaggaf, 2023; Hlongwane and Daw, 2023; Saidi et al., 2018; Bhattacharya et al., 2016; Nyoni and Phiri, 2020). In contrast, we found that non-renewable energy consumption (fossil fuels, nuclear energy, and alternative energy) had a different impact on economic growth under the GDP threshold. When GDP is below the threshold, fossil fuel consumption has a significant and positive impact on economic growth, with a coefficient of 3.375. Beyond the GDP threshold, the positive impact of fossil fuel consumption increases, with a coefficient of 3.439. The result indicates that economic growth rises with higher fossil fuel consumption, and this growth accelerates once the economy surpasses a specific GDP threshold. This phenomenon is because the economies of the sample countries rely primarily on fossil fuels due to their low costs and the availability of their infrastructure. This reliance on fossil fuels plays a fundamental role in promoting economic growth at all stages of economic development in these nations. Consequently, crossing this threshold increases the positive impact. This finding aligns with studies by (Shahbaz et al., 2020; Taasim et al., 2021; Bhat, 2018; Avis, 2020; Makrane and Bahari, 2025; Sasana and Ghozali, 2017; Mmbaga and Kulindwa, 2024; Effiong and Hosu, 2025; Zangoei et al., 2021; Asafu-Adjaye et al., 2016; Amaefule et al., 2022; Abbasi et al., 2020).

Furthermore, the results determine that nuclear and alternative energy consumption had a significant and positive impact on economic growth before reaching the GDP threshold. The coefficient before the threshold was 0.091, and this positive and significant impact remained after the GDP threshold, with a coefficient of 0.081. This result indicates a general positive relationship between nuclear and alternative energy and economic growth, but this effect diminishes upon reaching a certain level of GDP. The decrease may be due to increased financial burdens and the increased cost of establishing infrastructure dedicated to this type of energy. In this case, the economy benefits from alternative and renewable energy, but marginal revenues decrease in the long term as economic development levels increase. This finding aligns with studies by (Wolde-Rufael and Menyah, 2010; Yikun et al., 2021; Asif et al., 2021; Batool and Akbar, 2022).

The results of the fixed-effects panel regression indicate that the value of the fixed capital index was 0.0634, a positive value at a 1% significance level. This finding indicates a significant positive effect between fixed capital and economic growth; the result means that when the gross fixed capital formation increases by 1%, economic growth increases by 0.0634%. The impact of the labour force was positive and significant for economic growth; the results indicated that its coefficient was equal to 0.866 at the 1% significance level. This implies that a 1% increase in labour force size leads to a 0.866% increase in economic growth. This result is consistent with studies such as Sadorsky (2011), Omri (2013), and Poumanyvong and Kaneko (2010), particularly in developing and emerging countries. The coefficient for the carbon dioxide emissions index was found to be approximately 0.0033 at a 1% significance level. This result demonstrates a positive and significant relationship between CO_2 emissions and economic growth, providing strong evidence of the direct impact of emissions on economic growth in our study. The results also indicated that the urbanization coefficient was valued at −0.0073, which is significant at the 10% level. This suggests a negative impact on economic growth. This finding is consistent with Poumanyvong and Kaneko (2010) and Farhani and Shahbaz (2014), who reached the same conclusion and suggested that this effect is due to unplanned urbanization under environmental constraints and inadequate infrastructure, which impacts long-run growth. Conversely, the coefficient for the Organizational Quality Index was 0.180, indicating a significant positive effect on economic growth at the 1% significance level.

We conclude that the model explains approximately 89.14% of the variance among the countries studied, as indicated by an R^2 value of 0.8914. The F-test is significant at 1%, indicating that the model is significant. The rho test value of 0.98 shows that the variance is due to differences between countries, each with its own component. Furthermore, the $F(u_i = 0)$ test was significant at 1%, which confirms the importance of using a fixed effects model.

4.2. Renewable Energy Consumption Threshold Effect Test

The results, as shown in Table 4, indicate that the threshold value of renewable energy consumption was 3.1000 when using a robust method. This value falls between the upper value of 3.200 and the lower value of 3.00, based on a bootstrap sample size of 300. The F-statistic value was approximately 42.73 within a robust, which is greater than the critical values at the 10% (39.175) significance level. The probability value (Prob = 0.07) was lower than 10%, meaning that the test is statistically significant at the 10% level. Therefore, it can be concluded that introducing the threshold significantly improves the model and that the nonlinear model remains suitable for describing the relationship under study with the sample divided into different subsystems. The probability value (Prob = 0.07) is <10%, which means that the test is statistically significant at any of the significant levels. Therefore, the sequence threshold of model performance can be significant. This evidence indicates that when we exceed this threshold, the impact of renewable energy on economic growth becomes significant. Thus, a nonlinear relationship exists between renewable energy consumption and economic growth. Accordingly, when renewable energy consumption is below the threshold value (REC = 3.1000), renewable energy consumption has a significant and negative impact on economic growth, with a marginal coefficient of impact of −0.183. When renewable energy consumption is above the threshold value, the negative impact of renewable energy consumption on economic growth is significantly reduced, with a marginal coefficient of impact of −0.169.

In contrast, non-renewable energy consumption (fossil fuels, nuclear energy, and alternative energy) had a different impact on economic growth under the renewable energy consumption threshold. When consumption is below the threshold value, fossil fuel consumption has a significant and positive impact on economic growth, with a coefficient of 2.69. Beyond the renewable energy consumption threshold, the positive impact of fossil fuel consumption declines slightly, with a coefficient of 2.64. In addition, we determine that nuclear and alternative energy consumption had a strong, significant, positive impact on economic growth before reaching the renewable energy consumption threshold, with a coefficient before the threshold of 0.226. This positive and significant impact remained after the renewable energy consumption threshold, but the positive impact declined slightly, with a coefficient of approximately 0.062. This study indicates a general positive relationship between nuclear and alternative energy and economic growth, but this impact decreases when a certain level of renewable energy consumption is reached.

The results of the fixed-effects panel regression indicate that the value of the gross fixed capital formation index was 0.0930, a positive value, with a probability of <1% (P = 0.000). This result indicates a significant positive relationship at 1% with economic growth; it means that when the gross fixed capital formation increases by 1%, economic growth increases by 0.0930. The impact of the labour force was positive and significant for economic growth; the results showed that its coefficient equalled 1.317, with a probability of 0.000, which is <1%. This figure means that any increase in the labour force by 1% is accompanied by an increase in economic growth by 1.317. The results also showed that the urbanization coefficient has a value of −0.008867 with a probability of <5% (P = 0.048), which indicates a negative and significant impact. The coefficient for the Organizational Quality Index is 0.2049, a positive value that indicates a strong positive effect and significance, as the probability is P = 0.000.

The model quality results indicate that the model explains approximately 84.81% of the variance among the study countries, with an R^2 value of 0.8481. The F-test value is 145.7615 with a probability of <1%, indicating that the model is significant as a whole. The variance is due to differences between countries, and each country has its own component, as shown by the value of the rho test (rho = 0.98). Furthermore, the $F(u_i = 0)$ test was significant (P = 0.0000), which confirms the importance of using a fixed effects model.

These results suggest that the countries in the sample that still have <3% renewable energy consumption must work to increase investment in this sector to reach this threshold. Once reached, the focus should be on maximizing efficiency and increasing support for the institutional and regulatory framework, as institutional quality has had a positive impact. Therefore, efforts should be made to develop it to enhance GDP. Although non-renewable energy consumption has shown a positive impact, it should be reduced and support for renewable energy increased, given the significant impact of carbon dioxide on economic growth. Addressing labour market imbalances is also crucial, as there is a direct relationship between worker productivity and economic growth.

The results of the study in this section demonstrate that the threshold for renewable energy consumption reflects the impact of energy on economic growth. This finding is consistent with some literature. While our study demonstrated a nonlinear relationship between renewable and non-renewable energy consumption and economic growth, other studies disagree with this finding, including Apergis and Payne (2010) and Menegaki (2011), which concluded that renewable energy consumption has a weak impact on economic growth. In contrast, our study is consistent with Shahbaz et al. (2016), Mili et al. (2025), and Chen et al. (2020), which found a nonlinear relationship. In addition, our study is consistent with what was stated in the study of Makieła et al. (2022), which concluded that countries must reach a low threshold to begin benefiting from increased renewable energy production and that economies must reach a minimum developmental threshold before they can significantly benefit from increased renewable energy deployment. The results of the current study are also consistent with the findings of Feng and Zhao (2022) and Pata (2018), which suggest that the positive impact of renewable energy on growth only becomes apparent after significant diffusion rates within countries. This result suggests that the marginal benefit of renewable energy may be low at its low levels.

4.3. Non-Renewable Energy Consumption Threshold Effect Test

The results, as shown in Table 4, indicate that the threshold value of nonrenewable energy consumption was 99.240 when using a robust method. This value falls between the upper value of 99.3000 and the lower value of 99.2000, based on a bootstrap sample size of 300. Furthermore, the F-statistic value is greater than the critical values at the 1% significance level. Therefore, it can be concluded that introducing the threshold significantly improves the model and that the nonlinear model remains suitable for describing the relationship under study with the sample divided into different subsystems.

Accordingly, when fossil fuel use is below the threshold value, renewable energy consumption has a significant and negative impact on economic growth, with a marginal coefficient of impact of −0.238. When fossil fuel use is above the threshold value, the negative impact of renewable energy consumption on economic growth is significantly reduced, with a marginal coefficient of impact of −0.157. In contrast, non-renewable energy consumption (fossil fuels, nuclear energy, and alternative energy) had a different impact on economic growth under the threshold for fossil fuel consumption. When consumption is below the threshold value, fossil fuel consumption has a significant and positive impact on economic growth, with a coefficient of 2.80. Beyond the non-renewable energy consumption threshold, the positive impact of fossil fuel consumption declines slightly, with a coefficient of 2.76. In addition, we determine that nuclear and alternative energy consumption had a strong, significant, positive impact on economic growth before reaching the renewable energy consumption threshold, with a coefficient before the threshold of 0.060. This positive and significant impact remained after the non-renewable energy consumption threshold, but the positive impact declined slightly, with a coefficient of approximately −0.432. The result indicates a general negative relationship between nuclear and alternative energy and economic growth, but this impact decreases when a certain level of non-renewable energy consumption is reached.

The results of the fixed-effects panel regression indicate that the value of the fixed capital index was 0.1008, a positive value, with a probability of <1% (P = 0.000). This indicates a significant positive relationship at 1% with economic growth; this means that when the gross fixed capital formation increases by 1%, economic growth increases by 0.1008. In addition, the impact of the labour force was positive and significant on economic growth; the results showed that its coefficient equalled 1.113 with a probability (P = 0.000), which is <1%. This means that any increase in the size of the labour force by 1% is accompanied by an increase in economic growth by 1.113. The results also showed that the urbanisation coefficient has a value of (−0.00502) with a probability >10%, which indicates a negative but non-significant effect. The coefficient for the Organisational Quality Index was 0.124, indicating a strong positive effect and significance, as the probability is P = 0.000.

We conclude that the model explains approximately 86.60% of the variance among the countries studied, as indicated by an R^2 value of 0.8660. The F-test with a probability of <1% indicates that the model is significant as a whole. Furthermore, the $F(u_i = 0)$ test was significant at the 1% significance level, which confirms the importance of using a fixed effects model.

Overall, the results of the threshold test indicate a significant threshold for fossil fuel use. This means that the relationship between renewable and non-renewable energy consumption and economic growth varies across levels of fossil fuel consumption, with renewable energy having a negative impact on economic growth, while fossil fuel consumption has a significant positive impact on economic growth. In contrast, alternative energy has a significant positive effect; employment also has a strong positive effect. Urbanization has a positive but insignificant effect on growth. Results for the variables institutional quality and capital formation showed that these variables were strongly statistically significant with a positive effect.

5. CONCLUSION

This paper examined the impact of renewable and non-renewable energy consumption on economic growth. Panel threshold models were used for ten countries in the Middle East and North Africa that had all the available data for the study (Algeria, Egypt, Iraq, Lebanon, Libya, Morocco, Syria, Tunisia, Yemen, and Turkey) over the period 1996-2023. The findings demonstrated that the influence of the new energy transition threshold on economic growth is contingent upon the levels of gross domestic product, renewable energy consumption, and fossil fuel energy consumption. The overall conclusion is that the impact of renewable and non-renewable energy consumption on economic growth is non-linear, and this effect varies with levels of gross domestic product, renewable energy consumption, and fossil fuel energy consumption. The largely similar effect across the three thresholds, whether for GDP, renewable energy, or fossil fuels in terms of sign and significance, suggests that the relationship between renewable and non-renewable energy consumption is stable at different levels of the three thresholds. The evidence suggests that the behaviour of renewable and non-renewable energies is similar, which may indicate that the economy is at a single structural level and that structural transformation has not been sufficiently robust. The result supports the model's credibility, the absence of spurious relationships, the stability of the causal relationship, and the fact that the selection of the threshold is not random. On the other hand, despite this similarity in the results of all models in terms of sign and significance, we observe that the threshold at which economic growth changes varies with the type of threshold or threshold variable. Therefore, the interaction between renewable and non-renewable energy, on the one hand, and economic growth, on the other, is not restricted to a specific threshold, because each of the three threshold levels represents a different dimension of the economic dynamics of the countries in the study sample. The GDP threshold represents the different stages of economic development, the fossil fuel threshold defines the stages of transition in the overall energy structure, and the renewable energy threshold determines the extent of renewable energy penetration at certain levels of use.

In general, the sample countries' heavy reliance on traditional energy sources, such as fossil fuels and others, to boost production and economic growth will certainly lead to significant economic resistance, which will have a significant negative impact on economic growth. but with improved renewable energy infrastructure and reduced reliance on traditional or non-renewable energy, the negative impact will transform into a positive effect on economic growth in the long term.

REFERENCES

Abbasi, K., Jiao, Z., Shahbaz, M., Khan, A. (2020), Asymmetric impact of renewable and non-renewable energy on economic growth in Pakistan: New evidence from a nonlinear analysis. Energy Exploration and Exploitation, 38(5), 1946-1967.

Aghayeva, I., Zortuk, M. (2024), The impact of renewable and non-renewable energy consumption on economic growth in Azerbaijan: Fb-ardl and a-ardl cointegration approaches. Geo Science, 2, 119-133.

Al-mulali, U., Fereidouni, H.G., 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, 30, 290-298.

Al-Mulali, U., Fereidouni, H.G., Lee, J.Y., Sab, C.N.B.C. (2013), Examining the bi-directional long run relationship between renewable energy consumption and GDP growth. Renewable and Sustainable Energy Reviews, 22, 209-222.

Alper, A., Oguz, O. (2016), The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. Renewable and Sustainable Energy Reviews, 60, 953-959.

Amaefule, C., Kalu, I.E., Udeorah, S., Ebelebe, L.O. (2022), Fossil fuel consumption, CO_2 emissions, and growth in high-income countries and low-income countries. European Journal of Sustainable Development Research, 6(3), em0190.

Apergis, N., Payne, J. (2010), The emissions, energy consumption, and growth nexus: Evidence from the commonwealth of independent States. Energy Policy, 38, 650-655.

Apergis, N., Payne, J.E. (2010), Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy Policy, 38(1), 656-660.

Apergis, N., Payne, J.E. (2011), The renewable energy consumption-growth nexus in Central America. Applied Energy, 88(1), 343-347.

Apergis, N., Payne, J.E. (2012), Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. Energy Economics, 34(3), 733-738.

Asafu-Adjaye, J., Byrne, D., Alvarez, M. (2016), Economic growth, fossil fuel and non-fossil consumption: A pooled mean group analysis using proxies for capital. Energy Economics, 60, 345-356.

Asif, M., Bashir, S., Khan, S. (2021), Impact of non-renewable and renewable energy consumption on economic growth: Evidence from income and regional groups of countries. Environmental Science and Pollution Research International, 28(29), 38764-38773.

Avis, W. (2020), The use of Fossil Fuels in the Middle East and North Africa. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies. Available from: https://opendocs.ids.ac.uk/articles/report/the_use_of_fossil_fuels_in_the_middle_east_and_north_africa/26432617?file=48082390

Awodumi, O.B., Adewuyi, A.O. (2020), The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil producing economies in Africa. Energy Strategy Reviews, 27, 100434.

Azam, A., Rafiq, M., Shafique, M., Zhang, H., Ateeq, M., Yuan, J. (2021), Analyzing the relationship between economic growth and electricity consumption from renewable and non-renewable sources: Fresh evidence from newly industrialized countries. Sustainable Energy Technologies and Assessments, 44, 100991.

Azam, A., Rafiq, M., Shafique, M., Zhang, H., Yuan, J. (2021), Analyzing the effect of natural gas, nuclear energy and renewable energy on GDP and carbon emissions: A multi-variate panel data analysis. Energy, 219, 119592.

Balsalobre-Lorente, D., Ibáñez-Luzón, L., Usman, M., Shahbaz, M. (2022), The environmental Kuznets curve, based on the economic complexity, and the pollution haven hypothesis in PIIGS countries. Renewable Energy, 185, 1441-1455.

Batool, K., Akbar, M. (2022), The impact of nuclear energy consumption on economic growth and CO_2 emissions in selected Asian economies. Pakistan Journal of Humanities and Social Sciences, 10(3), 1015-1027.

Bhat, J.A. (2018), Renewable and non-renewable energy consumption-impact on economic growth and CO_2 emissions in five emerging market economies. Environmental Science and Pollution Research International, 25(35), 35515-35530.

Bhattacharya, M., Paramati, S.R., Ozturk, I., Bhattacharya, S. (2016), The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. Applied Energy, 162, 733-741.

Biala, M.I., Aromasodun, O.M., Shitu, A.M. (2025), Energy-growth nexus: A systematic review of empirical evidence and policy implications. African Journal of Environmental Sciences and Renewable Energy, 18(1), 178-197.

Bilgili, F. (2015), Business cycle co-movements between renewables consumption and industrial production: A continuous wavelet coherence approach. Renewable and Sustainable Energy Reviews, 52, 325-332.

Bilgili, F., Ozturk, I. (2015), Biomass energy and economic growth nexus in G7 countries: Evidence from dynamic panel data. Renewable and Sustainable Energy Reviews, 49, 132-138.

Bouoiyour, J., Selmi, R. (2013), The nexus between electricity consumption and economic growth in MENA countries. Energy Studies Review, 20(2), 25-41.

Can, H., Korkmaz, Ö. (2019), The relationship between renewable energy consumption and economic growth: The case of Bulgaria. International Journal of Energy Sector Management, 13(3), 573-589.

Carfora, A., Pansini, R.V., Scandurra, G. (2019), The causal relationship between energy consumption, energy prices and economic growth in Asian developing countries: A replication. Energy Strategy Reviews, 23, 81-85.

Chen, C., Pinar, M., Stengos, T. (2020), Renewable energy consumption and economic growth nexus: Evidence from a threshold model. Energy Policy, 139, 111295.

Dogan, E. (2015), The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey. Renewable and Sustainable Energy Reviews, 52, 534-546.

Durrani, S.F., Jan, I., Pervez, S. (2022), Renewable and non-renewable energy consumption and economic growth in Pakistan: A disaggregated analysis. Journal of Applied Economics Business Studies (JAEBS), 6(2), 77-94.

Effiong, M.O., Hosu, Y.S. (2025), Energy use and economic growth nexus in central Africa: A longitudinal analysis (1990-2023). International Journal of Energy Economics and Policy, 15(2), 164.

Elbadawi, I., Gelb, A. (2010), Oil, Economic Diversification and Development in the Arab World. In: Economic Research Forum Policy Research Report. Vol. 35.

Farhani, S., Shahbaz, M. (2014), What role of renewable and non-renewable electricity consumption and output is needed to initially mitigate CO_2 emissions in MENA region? Renewable and Sustainable Energy Reviews, 40, 80-90.

Feng, Y., Zhao, T. (2022), Exploring the nonlinear relationship between renewable energy consumption and economic growth in the context of global climate change. International Journal of Environmental Research and Public Health, 19(23), 15647.

Fuinhas, J.A., Marques, A.C. (2012), Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: An ARDL bounds test approach (1965-2009). Energy Economics, 34(2), 511-517.

Hamit-Haggar, M. (2016), Clean energy-growth nexus in Sub-Saharan Africa: Evidence from cross-sectionally dependent heterogeneous panel with structural breaks. Renewable and Sustainable Energy Reviews, 57, 1237-1244.

Hansen, B.E. (1999), Threshold effects in non-dynamic panels: Estimation, testing, and inference. Journal of Econometrics, 93(2), 345-368.

Hardle, W., Muller, M., Sperlich, S., Werwatz, A. (2004), Nonparametric and semiparametric models. In: Springer Series in Statistics. Heidelberg: Springer.

Hlongwane, N.W., Daw, O.D. (2023), Renewable electricity consumption and economic growth: A comparative study of South Africa and Zimbabwe. International Journal of Energy Economics and Policy, 13(3), 197-206.

Inglesi-Lotz, R. (2016), The impact of renewable energy consumption to economic growth: A panel data application. Energy Economics, 53, 58-63.

IRENA. (2024), Middle East and North Africa. International Renewable Energy Agency. Available from: https://www.irena.org/how-we-work/middle-east-and-north-africa

Ivanovski, K., Hailemariam, A., Smyth, R. (2021), The effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence. Journal of Cleaner Production, 286, 124956.

Jia, H., Fan, S., Xia, M. (2023), The impact of renewable energy consumption on economic growth: Evidence from countries along the belt and road. Sustainability, 15(11), 8644.

Kayani, F.N. (2021), Renewable energy and economic growth nexus: A case of United Arab Emirates. International Journal of Energy Economics and Policy, 11(5), 504-509.

Koçak, E., Şarkgüneşi, A. (2017), The renewable energy and economic growth nexus in Black Sea and Balkan countries. Energy Policy, 100, 51-57.

Lin, B., Moubarak, M. (2014), Renewable energy consumption-economic growth nexus for China. Renewable and Sustainable Energy Reviews, 40, 111-117.

Mahmood, H., Saqib, N., Adow, A.H., Abbas, M. (2023), Oil and natural gas rents and CO_2 emissions nexus in MENA: Spatial analysis. PeerJ, 11, e15708.

Makieła, K., Mazur, B., Głowacki, J. (2022), The impact of renewable energy supply on economic growth and productivity. Energies, 15(13), 4808.

Makrane, N., Bahari, K. (2025), Consommation d'énergies fossiles et croissance économique au Maroc: Quelle relation? Management control, auditing and finance review (MCAFR), 2(2), 221-231.

Menegaki, A.N. (2011), Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis. Energy Economics, 33(2), 257-263.

Mensah, I.A., Sun, M., Gao, C., Omari-Sasu, A.Y., Zhu, D., Ampimah, B.C., Quarcoo, A. (2019), Analysis on the nexus of economic growth, fossil fuel energy consumption, CO_2 emissions and oil price in Africa based on a PMG panel ARDL approach. Journal of Cleaner Production, 228, 161-174.

Mighri, Z., AlSaggaf, M.I. (2023), Asymmetric impacts of renewable energy consumption and economic complexity on economic growth in Saudi Arabia: Evidence from the NARDL model. Environmental Science and Pollution Research International, 30(3), 7446-7473.

Mili, K., Bengana, I., Aouini, S., Hezla, M. (2025), Threshold effects of renewable energy and environmental R&D on green growth: A dynamic panel analysis of OECD countries. Energy Reports, 14, 2368-2383.

Mmbaga, N.F., Kulindwa, Y.J. (2024), Energy consumption and economic growth: Evidence from electricity and petroleum in Eastern Africa Region. Clean Energy and Sustainability, 2(4), 10019.

Mohammadi, H., Parvaresh, S. (2014), Energy consumption and output: Evidence from a panel of 14 oil-exporting countries. Energy Economics, 41, 41-46.

Nyoni, B., Phiri, A. (2020), Renewable energy: Economic growth nexus in South Africa: Linear, nonlinear or non-existent? International Journal of Energy Economics and Policy, 10(6), 635-644.

Ocal, O., Aslan, A. (2013), Renewable energy consumption-economic growth nexus in Turkey. Renewable and Sustainable Energy Reviews, 28, 494-499.

Okui, R., Yanagi, T. (2020), Kernel estimation for panel data with heterogeneous dynamics. The Econometrics Journal, 23(1), 156-175.

Omri, A. (2013), CO_2 emissions, energy consumption and economic growth nexus in MENA Countries: Evidence from simultaneous equations models. Energy Economics, 40, 657-664.

Osman, M., Gachino, G., & Hoque, A. (2016). Electricity consumption and economic growth in the GCC countries: Panel data analysis. Energy Policy, 98, 318-327.

Ozturk, I. (2010), A literature survey on energy-growth nexus. Energy Policy, 38(1), 340-349.

Ozturk, I., Bilgili, F. (2015), Economic growth and biomass consumption nexus: Dynamic panel analysis for Sub-Sahara African countries. Applied Energy, 137, 110-116.

Pao, H.T., Fu, H.C. (2013), Renewable energy, non-renewable energy and economic growth in Brazil. Renewable and Sustainable Energy Reviews, 25, 381-392.

Pata, U.K. (2018), Renewable energy consumption, Urbanization, financial development, income and CO_2 emissions in turkey: Testing EKC hypothesis with structural breaks. Journal of Cleaner Production, 187, 770-779.

Payne, J.E. (2009), On the dynamics of energy consumption and output in the US. Applied Energy, 86(4), 575-577.

Poumanyvong, P., Kaneko, S. (2010), Does Urbanization lead to less energy use and lower CO_2 emissions? A cross-country analysis. Ecological Economics, 70, 434-444.

Rafindadi, A.A., Ozturk, I. (2015), Natural gas consumption and economic growth nexus: Is the 10th Malaysian plan attainable within the limits of its resource?. Renewable and Sustainable Energy Reviews, 49, 1221-1232.

Rahman, M.M., Zahan, F., Islam, M.F. (2024), Energy finance strategy and governance nexus with economic growth: Results from emerging economies. PLoS One, 19(12), e0314286.

Rahman, M.R., Rahman, M.M., Akter, R. (2024), Renewable energy development, unemployment and GDP growth: South Asian evidence. Arab Gulf Journal of Scientific Research, 42(3), 1044-1059.

Raza, S.A., Shah, N., Khan, K.A. (2020), Residential energy environmental Kuznets curve in emerging economies: The role of economic growth, renewable energy consumption, and financial development. Environmental Science and Pollution Research, 27(5), 5620-5629.

Resource Governance. (2025), Energy Transition and Regional Collaboration in the Middle East and North Africa. Natural Resource Governance Institute. Available from: https://resourcegovernance.org/publications/energy-dilemma-energy-transition-regional-collaboration-middle-east-north-africa

Ruckthongsook, W., Tiwari, C., Oppong, J.R., Natesan, P. (2018), Evaluation of threshold selection methods for adaptive kernel density estimation in disease mapping. International Journal of Health Geographics, 17(1), 10.

Sadorsky, P. (2011), Financial development and energy consumption in central and Eastern European frontier economies. Energy Policy, 39, 999-1006.

Saidi, H., El Montasser, G., Ajmi, N. (2018), Renewable Energy, Quality of Institutions and Economic Growth in MENA Countries: A Panel Cointegration Approach. Munich Personal RePEc Archive (MPRA), Paper 84055.

Salamaliki, P.K., Venetis, I.A. (2013), Energy consumption and real GDP in G-7: Multi-horizon causality testing in the presence of capital stock. Energy Economics, 39, 108-121.

Salehin, M., Kiss, J. (2022), Testing the causal relationship between economic growth and renewable energy consumption: Evidence from a panel of EAGLE countries. International Journal of Energy Economics and Policy, 12(1), 281-288.

Salim, R.A., Rafiq, S. (2012), Why do some emerging economies proactively accelerate the adoption of renewable energy? Energy Economics, 34(4), 1051-1057.

Sarsar, L., Echaoui, A. (2024), Empirical analysis of the economic complexity boost on the impact of energy transition on economic growth: A panel data study of 124 countries. Energy, 294, 130712.

Sasana, H., Ghozali, I. (2017), The impact of fossil and renewable energy consumption on the economic growth in Brazil, Russia, India, China and South Africa. International Journal of Energy Economics and Policy, 7(3), 194-200.

Shahbaz, M., Khraief, N., Czudaj, R.L. (2020), Renewable energy consumption-economic growth nexus in G7 countries: New evidence from a nonlinear ARDL approach. Economics Bulletin, 40(4), 2828-2843.

Shahbaz, M., Loganathan, N., Zeshan, M., Zaman, K. (2015), Does renewable energy consumption add in economic growth? An application of auto-regressive distributed lag model in Pakistan. Renewable and Sustainable Energy Reviews, 44, 576-585.

Shahbaz, M., Mallick, H., Mahalik, M.K., Sadorsky, P. (2016), The role of globalization on the recent evolution of energy demand in India: Implications for sustainable development. Energy Economics, 55, 52-68.

Shahbaz, M., Van Hoang, T.H., Mahalik, M.K., Roubaud, D. (2017), Energy consumption, financial development and economic growth in India: New evidence from a nonlinear and asymmetric analysis. Energy Economics, 63, 199-212.

Sijabat, R. (2024), The long-run relationship between renewable energy consumption, non-renewable energy consumption, population, and economic growth in G20 Countries. International Journal of Sustainable Development Planning, 19(4), 1599-1610.

Taasim, S.I., Pinjaman, S., Albani, A. (2021), Does energy consumption and trade openness contribute to economic growth in the East Asian growth area? International Journal of Energy Economics and Policy, 11(2), 23-29.

Tiwari, A.K. (2011), A structural VAR analysis of renewable energy consumption, real GDP and CO_2 emissions: Evidence from India. Economics Bulletin, 31(2), 1793-1806.

Wang, Q. (2015), Fixed-effect panel threshold model using Stata. The Stata Journal, 15(1), 121-134.

Wang, Q., Dong, Z., Li, R. (2023), Revisiting renewable energy and economic growth-Does trade openness a matter? Environmental Science and Pollution Research International, 30(11), 31727-31740.

Wang, Q., Jiang, R., Zhan, L. (2019), Is decoupling economic growth from fuel consumption possible in developing countries? -a comparison of China and India. Journal of Cleaner Production, 229, 806-817.

Wang, Q., Yang, X., Li, R., Yang, T. (2024), Revisiting the impact of renewable energy on carbon emission in 130 countries-the mediating effect of resource rental rents and human capital. Energy Environment, 35(8), 4083-4113.

Wang, Y., Zuo, Y., Li, W., Kang, Y., Chen, W., Zhao, M., Chen, H. (2019), Does environmental regulation affect CO_2 emissions? Analysis based on threshold effect model. Clean Technologies and Environmental Policy, 21(3), 565-577.

Wolde-Rufael, Y., Menyah, K. (2010), Nuclear energy consumption and economic growth in nine developed countries. Energy Economics, 32(3), 550-556.

Xie, F., Liu, C., Chen, H., Wang, N. (2018), Threshold effects of new energy consumption transformation on economic growth. Sustainability, 10(11), 4124.

Yikun, Z., Gul, A., Saleem, S., Shabbir, M.S., Bilal, K., Abbasi, H.M. (2021), The relationship between renewable energy sources and sustainable economic growth: Evidence from SAARC countries. Environmental Science and Pollution Research, 28(25), 33390-33399.

Yildirim, E., Aslan, A. (2012), Energy consumption and economic growth nexus for 17 highly developed OECD countries: Further evidence based

on bootstrap-corrected causality tests. Energy Policy, 51, 985-993.
Yildırım, E., Sukruoglu, D., Aslan, A. (2014), Energy consumption and economic growth in the next 11 countries: The bootstrapped autoregressive metric causality approach. Energy Economics, 44, 14-21.
Zangoei, S., Salehnia, N., Khodaparast Mashhadi, M. (2021), A comparative study on the effect of alternative and fossil energy consumption on economic growth and foreign direct investment in selected countries using SUR approach. Environmental Science and Pollution Research International, 28(16), 19799-19809.