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Identifying the factors that drive renewable energy consumption in the MENA region

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Abstract

The present study aims to identify the factors that drive renewable energy consumption in the MENA region. For this aim, the study employed panel data that consist of seven selected countries namely Algeria, Morocco, Egypt, Iraq, United Arab Emirates, Qatar, and Saudi Arabia from 2000 to 2021. The current study performed a Panel ARDL and causality test to determine the long-run effect of the variables and the direction of these effects. With that in mind, the study unveiled that energy importation and national income have a detrimental impact on renewable energy consumption while indicators such as inflation, government expenditure, economic growth, and industrial sector performance uncovered to rise the renewable energy consumption in MENA countries. Interestingly, the trade coefficient revealed no remarkable impact on the dependent variable. The results will offer insights to the MENA nations and the countries struggling to promote renewable energy consumption by identifying the factors that need to be prompted in order to increase the consumption of renewable energy and dissociate from non-renewable energy without compromising to achieve sustainable economic development. The paper also contributes to the literature by establishing a link between macroeconomic and microeconomic factors on energy consumption.

Keywords: Renewable energy, Energy consumption, Energy output, Income, Economic factors, MENA

JEL Codes: O13, Q42, Q43

1. Introduction

Growth and energy are observed to be positively correlated. Energy consumption rises along with economic expansion, particularly the need for fossil fuels. Renewable energy sources are low-carbon and environmentally beneficial. Consequently, many nations have embraced renewable energy technology to protect the environment in recent years. Moreover, a number of variables, including the security of the energy supply, energy reliance, global warming, the volatility of energy prices, health concerns, and environmental disasters, spurred rising economies to use renewable energy sources (Akbarc et al., 2021:473).

In order to achieve and maintain economic growth over the long run, energy production and consumption are essential. As non-renewable energy sources like fossil fuels (coal, gas, and petroleum) increase overall CO2 emissions while also tending to increase the cost of energy over time, energy production and consumption have also given rise to significant environmental issues. In many regions of the world, rising expenses have led to circumstances where a lack of energy has not only led to economic challenges but also appears to have resulted in an increase in poverty and issues with environmental change as a consequence of rising CO2 emissions (Cheng et al., 2021:3).

Nations especially the MENA region that consists of the most producing petrol on the planet are always looking for new sources of energy that can be supplied and at the same time do not damage the Earth's ecology due to the rise in global energy demand. The overall cost of renewable energy is one of its main benefits because it is substantially less expensive than traditional, fossil fuel-based energy. Because, two significant issues have been created by the economic expansion and reliance on fossil fuels for energy needs: the first is maintaining economic development, and the second is assuring a steady supply of energy at reasonable rates (Ahmed & Shimada, 2019:2).

In the long run, the overall cost savings from using innovative or green renewable resources can be used to increase the general quality of life for individuals while also allowing governments to address

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environmental concerns. Because energy consumption accounts for a large portion of the country's overall economic growth, the significance of renewable energy cannot be overestimated. Energy consumption and economic development go synonymously, and all gulf nations are currently categorized as upper-middle-income economies. The demand for energy is rising as a result of the quickening rate of economic development. In the MENA region, conventional fossil fuels continue to be the dominant energy source which drives them to seek a new alternative source of energy in a world that is changing rapidly (Sarkodie & Strezov, 2019: 863).

According to Ahmed and Sarkar (2018), the environment should not be harmed by renewable resources, they should be limitless, and alternative sources should be inexpensive over long periods of time while still fulfilling community needs and complying with current and future civil laws. This implies that the distribution of renewable energy, which has a positive impact on robust green growth and is essential for the shift to a green economy, can provide short-term socioeconomic benefits. Additionally, pricing for renewable energy is less important in nations with low-cost growth. Another study by Przychodzen (2020) documented that expectations about technical and economic development affect how much primary energy is consumed. The country's economy and future are significantly dependent on the growth of the energy industry. The only resource that can support the nation's development needs is energy. The country's future development depends heavily on the energy industry because it needs to grow into a competitive nation and maintain steady economic growth.

One major reason that arose the investment into renewable energy was the oil crisis of 1973, also known as the C74 crisis, and its effects on the OECD countries during this time helped give rise to the unit elasticity theory, which seeks to assess the change in economic growth about change in energy consumption (Namahoro et al., 2021). In another paper authors such as Ohler and Fetter (2014:129), investigated if there were causal links between economic growth and the production of power from renewable sources including wind, hydroelectricity, geothermal energy, etc. using data from 20 OECD nations spanning the years 1990 to 2008. They implement the production function's framework. The findings suggested that the factors under consideration had a co-integrated relationship. Granger's causality test revealed a positive bidirectional association between short-term GDP growth and hydroelectricity. Their results also showed that, among renewable energy sources, hydroelectricity has a significant long-term influence on real GDP. Murshed (2018) gathered data from a few South Asian economies. Additionally, particular research from industrialized economies claimed that the promotion of trade openness made easier the transition to renewable energy.

Muhammad (2019:240) used the generalized method of moments (GMM) for data analysis to investigate the impact of economic growth, energy consumption, and pollution emissions for 68 nations from 2001 to 2017 for developed, emerging, and MENA Countries. The findings of this study confirmed that economic growth increased in developed and developing countries with increased energy consumption, whereas it decreased in MENA countries. Pollution emissions increased in all countries as a result of increased energy consumption. Due to an increase in pollutant emissions, energy consumption is on the up in every country, but economic growth is on the rise in every country except MENA.

Using the Maximum Entropy approach, Gul et al. (2015: 7) looked at the link between carbon dioxide emissions and energy demand in Malaysia between 1975 and 2013. The outcomes demonstrated that energy use degrades environmental quality. Granger's causality test findings also indicated that the rise in energy demand is to blame for the increase in carbon dioxide emissions per person. In a different work, he used the ARDL method to examine the long- and short-term effects of fossil fuel consumption, foreign direct investment, and economic growth on carbon dioxide emissions in 15 emerging Asian nations from 1990 to 2013. The findings demonstrated that consumption of fossil fuels and foreign direct investment increase the region's carbon dioxide levels, whereas economic expansion in developing nations increases carbon dioxide emissions. Between 1990 and 2016, Nathaniel and Khan (2020:6) also investigated the connections between urbanization, renewable energy, trade, and ecological footprint in ASEAN nations. The findings show that environmental degradation in ASEAN countries is favourably impacted by economic growth, trade, and non-renewable energy sources and that the cost of environmental degradation in this region is rising.

The current work is novel primarily because the cointegration approaches are rarely used while inspecting a wide geographic analysis. Next, the paper performed a PMG-ARDL model to investigate the results from a long and short-term perspective, and causality analysis to identify the direction of these results. With this, the empirical findings will provide various scenarios about the phenomena investigated. Moreover, previous studies have either concentrated on developed countries or around BRICS countries, therefore, not shedding enough light on the situation of the MENA region when it comes to energy consumption.

Consequently, the paper aims to identify the factors that drive renewable energy consumption in the MENA region. Hereby, the paper employs panel data that consist of seven selected countries namely Algeria, Morocco, Egypt, Iraq, United Arab Emirates, Qatar, and Saudi Arabia from the period 2000 to 2021. What is more, the study considered renewable energy consumption as dependent variable. Further, the study selected factors such as Energy imports, national income, Inflation, government expenditure, GDP, Trade, and Manufacturing, value added as potential drivers for renewable energy. Within this scope, to carry on with the examination a PMG-ARDL and granger causality tests were employed. The models will help us to determine the effects resulting from the variables in proportion to the researched phenomena in the long-run.

The format of this article is described in the following. The available literature is reviewed in the second part. The third section provides information on the sources and usage of the data as well as the econometric model. The fourth section interprets the empirical findings. The paper is concluded in the fifth section.

2. Literature Review

Certain significant events and advances throughout the world have expedited the switch from non-renewable streams to alternatives. Rising worries over power generation, environmental degradation, political and societal tension to reduce atmospheric carbon (GHG) emissions, high and unstable crude prices, and a strong reliance on overseas energy supplies are only a few of these issues. Due to these worries, renewable energy sources including wind, solar, geothermal, biomass, wave, and others have moved to the forefront of discussion. In order to guarantee power production and broaden the energy market, many nations are currently increasing their investments in their low-carbon sectors and bolstering them with a variety of national policies, including payroll taxes for renewable energy supply, special offers for implementing sustainable energy systems, renewable energy portfolio indicators, and the creation of markets for renewable energy certificates. (Ozcan and Ozturk, 2019:30).

The scientific evidence on the relationship between energy use and determining variables is extensive and rising, particularly in the wake of Kraft's (1978) important work on the US economy. The study included a wide range of nations and covered diverse time periods with a variety of methodological stances (Armeanu et al., 2021: 3).

A number of these researchers looked at the associations between revenue from sustainable and non-renewable sources of energy. For instance, Salim et al. (2014:23) uncovered indications supporting the feedback hypothesis for the relationship between economic development and the utilization of non-renewable energy in the temporarily, whereas the growth assumption was supported in the scenario of the relationship between economic development and the intake of renewable energy in the short term. In this research thread, the use of renewable power and economic development. Apergis and Payne (2012:736) supported both the feedback and conservation hypotheses. Moreover, both in the short and long runs, the non-renewable electricity demand-economic performance situation validated the feedback theory. According to research done on a single nation, environmental degradation in Pakistan would increase by 1.03% for every 1% increase in economic growth, according to (Khan et al., 2020:9). Indonesian economic development and CO_2 emissions have a two-way causal relationship, according to (Shahbaz et al., 2013: 27).

The impact of renewable and non-renewable power consumption on output in Latin American nations was examined by (Al-Mulali et al., 2014: 296). They discovered long-term causal relationships between the use of power, labor, commerce, and renewable and non-renewable energy sources. Their empirical investigation showed that in order to sustain economic growth, renewable power is significantly more crucial than nonrenewable electricity

Lin and Moubarak (2014: 115) used an autoregressive distributed lag (ARDL) technique to serial correlation, encompassing sporadic variables like carbon dioxide emissions and manpower, to analyze the link between China's adoption of renewable energy and economic development. Their research demonstrates a long-term bi-directional causal relationship between the usage of sustainable energy and economic expansion. They also pointed out that China's rising economy is favorable for the development of renewable energy, which helps to increase productivity expansion.

Eren et al. (2019: 195) extensively investigated the impact of India's usage of renewable energy on financial development and economic growth by taking economic advancement, the consumption of renewable energy, and these factors into account as additional drivers. Their findings show that the renewable energy consumption and economic growth in India are driven by long-term capital formation and that there is a bi-directional causal relationship between these two variables.

By supporting an unbalanced association between oil values, borrowing costs, and the stock prices of clean energy and technology companies, Kocaarslan and Soytas (2019:122) have made a significant contribution to the body of current knowledge. They discovered that the effects of favorable and negative changes in oil prices, interest rates, and innovation stock prices on clean energy stock prices varied significantly in the short-run and long run using a newly created methodology known as the NARDL model. They also noted that uncertain threats and a brief surge in oil prices are frequently to blame for the increasing investment in renewable energy equities. On the other hand, the long-term price of clean energy equities is negatively impacted by the growing oil price, and this effect is asymmetric.

Shah et al. (2020: 8) recently looked at the connection between economic progress, sustainable sources, and CO_2 emissions in underdeveloped nations. Their findings show that alternative sources have a favorable and significant relationship with economic success, whereas CO_2 emissions had a negative impact. As a consequence, they advocated for incorporating more renewable energy in the prevailing infrastructure to boost economic development and for environmental safety.

Employing panel data from 74 nations from 1990 to 2015, Sharif et al. (2019:8) investigated the relationship between renewable and nonrenewable energy use and CO_2 emissions. Their research also demonstrates that the consumption of non-renewable energy has a favorable influence on environmental deterioration whereas the use of renewable energy has a negative impact and contributes to the reduction of pollutants. In a similar vein, ecological deterioration is significantly and negatively impacted by economic expansion.

Shahbaz et al. (2015: 581) looked into how using renewable energy may improve financial prosperity in Pakistan. A range of quarterly data from the years 1972 to 2011 was used in the study. Using ARDL's approach, the study's findings demonstrated that Pakistan's long-term financial developments are significantly influenced by its usage of renewable energy. The study also used VECM Granger causality to examine the causal relationship between the variables. The results of the research showed a causal response relationship between the use of renewable energy and the nation's financial viability.

Most recently, Troster et al. (2018: 33) looked at the relationship between oil prices, economic growth, and green energy in the US. The dataset for the study spans 28 years, from 1989 to 2016. To examine the causal relationship between the researched variables, the study used the most contemporary econometric techniques of granger causality in quantiles. The findings of the empirical study support the hypothesis that the variables exhibit feedback causality.

Menegaki (2011: 262) also looked into the link between the use of renewable energy and economic growth. 27 European countries were examined in the study between 1997 and 2007. Contrary to Fang (2011), the study's findings revealed no link between renewable energy and the financial development of five of the six studied countries (Estonia, Poland, Hungary, Cyprus, and Slovenia).

Over the years 1971–2011, Alabi et al. (2017: 16) explored at the relationship between the per-capita use of renewable energy and economic growth in three OPEC nations in Africa: Angola, Algeria, and Nigeria. Their research found a long-term and short-term causal relationship between REC and GDP per capita.

Omri et al. (2015: 2920) also verified a similar relationship between real GDP per capita and renewable energy consumption per capita for a panel of 64 nations. They also discovered that trade openness is a factor in renewable energy consumption per capita, in contrast to Ben Aissa et al. (2014:17) uncovered that there is no immediate or long-term relationship between trade and renewable energy consumption. Similar findings were made by Salim and Rafiq (2012), who concluded that wealth considerably and favorably influences renewable energy consumption in six emerging economies. Moreover, Rasoulinezhad and Sabori (2018) identified that trade and financial openness had a favorable impact on REC.

Cadoret and Padovano (2016) also emphasized the significance of democratic institutions in promoting renewable energy. They came to the conclusion that whereas oil and natural gas conglomerates and monopolists have a negative influence on renewable energy deployment, the rule of law has a positive impact. Liberal political parties promote renewable energy development more than conservative ones, according to the authors. Generally, it is believed that effective renewable energy promotion is facilitated by high-quality governance.

Hvelplund (2013) discussed the political evolution of Denmark in relation to its experience with renewable energy promotion. The adoption of renewable energy technology was the starting point for the author's division of Danish renewable energy development into two major phases, while the competitiveness of renewable energy on the market was the second. It was shown that in order to counteract the potentially damaging impact of powerful industrial organizations (in this example, the representatives of the oil and gas industries) and political lobbyists, democratic systems and governmental transparency are essential for the second phase. According to the author, creative democracy is a political system in which the interests of all enterprises (including the weakest ones), are linked to effective renewable energy development deployment in Denmark

It is evident from reading the extensive body of pertinent literature that renewable energy is a serious issue. Diverse studies have looked at the subject from a variety of angles and with various factors. However, the factors affecting renewable energy's use and output have not been examined in any earlier study. In an era where everyone strives to be emission-free and prevent global warming, all of this evidence supports performing a study to discover what motivates nations to use renewable energy.

3. Methodology

3.1. Data sources and Description

The current study examines the factors that drive renewable energy consumption in the MENA region. Hereby, the paper employs panel data that consist of seven selected countries namely Algeria, Morocco, Egypt, Iraq, United Arab Emirates, Qatar, and Saudi Arabia from the period 2000 to 2021. This region is selected because it is home to 2/5 of the world's natural gas resources and maintains more than half of the world's oil reserves. The region produces a substantial amount of natural gas and crude oil, making it a significant source of economic and energy supplies for the world. However, a number of MENA economies are consciously readjusting their economies to lessen their reliance on exports of fossil fuels. For instance, the IT industry in the United Arab Emirates is booming, while Qatar is growing its financial services industry and Egypt has implemented rules since 2008 to prioritize renewable energy consumption. Based on this fact, the study considered renewable energy consumption as dependent variable. What is more, the study selected factors such as Energy imports, national income, Inflation, government expenditure, GDP, Trade, and Manufacturing value added as potential drivers for renewable energy. In summary, the process of selecting the macro determinants of renewable energy consumption in this study was based on reviewing the literature, identifying relevant macroeconomic factors, considering data availability and quality, testing for multicollinearity, and finally choosing the most appropriate econometric method to estimate the relationship. Within this scope, to carry on with the examination a PMG-ARDL and granger causality tests were employed. The models will help us to determine the effects resulting from the variables in proportion to the researched phenomena in the long run. And determine the direction of the variables. Overall, Panel ARDL is a powerful and flexible method that can be used to estimate the long-run relationship between variables in a panel data set, while accounting for non-stationarity, heterogeneity, and other common challenges in econometric analysis (Olayungbo & Quadri, 2019). All the information was extracted from the World Bank Indicators.

Table 1. Description of variables

Variable	Abbreviation	Description	Measurement
Dependent	RE	Renewable energy consumption	Renewable energy consumption (% of total final energy consumption)
Independent	IM	Energy importation	Energy imports, net (% of energy use)
	IC	National income	The logarithm of adjusted net national income (current US$)
	IF	Inflation	Inflation, consumer prices (annual %)
	GVE	Government expenditure	Final consumption expenditure (% of GDP)
	GDP	Economic growth	The logarithm GDP (current US$)
	TRA	Trade	Trade (% of GDP)
	MV	Industrial sector performance	The logarithm of Manufacturing, value added (current US$)

3.2. Econometric Model

The paper considers examining the determinants of renewable consumption in MENA region. The following equation provides an overview of the study's overall framework.

$$RE_t = \int (IM_t, IC_t, IF_t, GVE_t, GDP_t, TRA_t, MV_t) \tag{1}$$

The relationships are examined by employing the Panel ARDL method. The inconvenience of employing the cointegration method for analyzing series with different degrees of cointegration is overcome by the Panel ARDL method. The advantage of such an approach involves the fact that it investigates whether a cointegration relationship exists between the variables, regardless of the degree to which the variables are cointegrated (Pesaran et al., 1999). The PMG estimator is utilized for estimating the panel ARDL. This estimator is preferred for estimating dynamic panels with a large number of cross-sections and time. The PMG estimator allows for estimating different constant terms, different error variances, and short-term impacts for each cross-section unit. Besides, the value of the concordance coefficient can be estimated by employing the PMG method. The concordance coefficient is the estimated value of the coefficient of error correction term in the model exhibiting short-term impacts. By courtesy of this coefficient, the degree of concordance realized in each period can be determined. In other words, the time required to reach a new equilibrium due to a disparity can be determined with the help of this coefficient (Pesaran & Smith, 1995). The ARDL model for a certain period and a certain number of units is shown in Equation (2).

$$\Delta y_{it} = \emptyset_i[y_{i,t-1} - \lambda'_i \mathrm{X}_{i,t}] + \sum_{j=1}^{p-1} \xi_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \beta'_{ij} \Delta \mathrm{X}_{i,t-j} + \varphi_i + e_{it} \tag{2}$$

$$\Delta \mathrm{RE}_{it} = \emptyset_i[\mathrm{RE}_{i,t-1} - \lambda'_i \mathrm{X}_{i,t}] + \sum_{j=1}^{p-1} \xi_{ij} \Delta \mathrm{RE}_{i,t-j} + \sum_{j=0}^{q-1} \beta'_{ij} \Delta \mathrm{X}_{i,t-j} + \varphi_i + e_{it} \tag{3}$$

In the equation above the dependent variable $\Delta \mathrm{RE}_{it}$ which is the renewable energy consumption is expressed in form of panel ARDL. Additionally, we have the X_{it}which implies the vector of our independent variables it includes factors such as Energy importation (IM_{it}), National income (IC_{it}), Inflation (IF_{it}), Government expenditure (GVE_{it}), Economic growth (GDP_{it}), Trade (TRA_{it}), and

Industrial sector performance (MV_{it}). λ'_i are the lag coefficients of our mains factors. ξ_{ij} and β'_{ij} are the short run-dynamic coefficients.

Cross section dependence

To obtain accurate estimates from a panel data analysis, it is crucial to recognize the cross-sectional dependency (CD). By taking into account the situation where a shock in one country's variable influences the same variable in other nations, we can use this example to explain the notion of CD. The findings might result in erroneous predictions if the CD is not taken into account in the model. Hence, appropriate econometric procedures that take CD into account should be used to provide estimates that can be trusted. In this respect, the current work offers an estimating approach that may handle CD-related concerns in addition to diagnosing cross-sectional dependency. To examine the relationships between the cross-sectional units, the study used a variety of cross-sectional dependence tests, including the Breusch-Pagan LM test created by Breusch & Pagan (1980), the Pesaran scaled LM test developed by Pesaran (2007), and the Pesaran CD test proposed by Pesaran (2021). The equation below represents the model.

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=0}^{N-1}\sum_{j=i+1}^{N} pij\right)} \tag{4}$$

In the equation, CD stands for cross-sectional dependency, N represents the frequency of cross-sections, T indicates the approximate time, and represents the correlation between i and j cross-sectional error.

Panel Unit Root Test

Regression of non-stationary data without cointegration may provide erroneous regression. So, it is crucial to determine the correct sequence for integrating the variables. There are a few tests we may do to see if the panel data remains constant. For instance, Maddala and Wu (1999) and Choi (2001) modified all the first-generation panel unit root tests. Nevertheless, the fundamental drawback of these tests is their inability to account for CD faults, which is why they are sometimes referred to be first-generation panel unit root tests. So, we tested the unit root of each time series using Cross-section Augmented Dickey-Fuller (CADF) and Cross-section Im-Pesaran-Shin (CIPS) tests. The formula for the unit root is:

$$X_{it} = \delta_{it} + \vartheta_{iXit-1} + \gamma_i T + \sum\nolimits_{i=1}^{n} \pi_{ij}\Delta_{Xij-j} + \varepsilon_{it} \tag{5}$$

Based on equation (5) X_{it}represents the regressors, δ_{it} is the intercept, T shows the time period, Δ denotes the difference operative, and ε_{it} signifies the error term.

Panel Causality Test

Due to its superiority over the traditional Granger causality test in the context of CD and slope heterogeneity, the Dumitrescu-Hurlin panel causality test was used in the current investigation. The null hypothesis for the Dumitrescu-Hurlin causality test is homogeneous non-causality. In order to dismiss the null hypothesis and draw the conclusion that the regression coefficient under consideration causes the dependent variable, a substantial p-value of the z-statistic is required (Dumitrescu & Hurlin, 2012).

$$\Delta Y_{it} = \alpha_i + \sum_{j=1}^{j} \lambda_i^{(j)} Y_{i,t} + \mu_{it} \tag{6}$$

In Equation (6), X and Y are the variables in which causality will be estimated and j is the optimum lag interval. This test was used to detect whether X causes Y or not.

4. Findings and Interpretations

Table 2 displays the descriptive statistics for the variables. RE show an average value of 0.31% for the selected period. Additionally, the table records a maximum value of 23% for RE. Based on the results, IM, and GVE revealed the largest standard deviation values, indicating that these components had a high level of volatility. In addition, the distribution is negatively skewed for all the variables except IM.

Table 2. Descriptive statistics

	RE	IM	IC	IF	GVE	GDP
Median	0.3150	-212.36	11.112	2.8309	61.600	11.221
Maximum	23.000	90.940	11.816	53.230	98.216	11.920
Minimum	0.0100	-545.20	9.9483	-10.067	24.450	10.243
Std. Dev.	5.0150	42.00	0.3783	7.5556	18.034	0.3627
Skewness	-0.7801	0.2682	-0.3674	-0.9348	-0.0282	-0.2889
Kurtosis	2.40280	2.0424	3.1667	2.773	2.2615	3.0152
Observations	154	154	154	154	154	154

Table 3 expresses the correlation matrix between the variables. According to the results, all the variables exhibit a moderate negative correlation with RE except for IM and GVE. The absence of high correlation coefficients allows the exclusion of the multicollinearity possibility among the variables. Additionally, determining multicollinearity based on the correlation matrix is not robust. As consequence, the Variance inflation factor is carried on to estimate the relationship among the explanatory factors in regression models. To be precise the more VIF rises the less authentic and reliable the regression results will be. For instance, a VIF over 10 demonstrates an excessive correlation and reason for worry. Mostly, the authors propose a safe degree of 5 to 10. Hence in conformity with the table 3 outcome, all the variables have a variance of less than 7 which suggest that the study is free from multicollinearity. (Myers, 1990).

Table 3. Matrix of correlation

Variables	RE	IM	IC	IF	GVE	GDP	TRA	MV
RE	1.000							
IM	0.815	1.000						
IC	-0.253	0.149	1.000					
IF	-0.075	-0.022	-0.203	1.000				
GVE	0.591	0.815	0.180	0.110	1.000			
GDP	-0.317	0.072	0.993	-0.205	0.105	1.000		
TRA	-0.314	-0.296	0.070	0.060	-0.537	0.070	1.000	
MV	-0.087	0.161	0.669	-0.347	0.153	0.670	-0.181	1.000
VIF	[redacted]	3.62	7.50	1.32	4.94	7.37	1.62	1.32

The rejection of the null hypotheses indicates that the residuals are cross-sectionally dependent, according to the three distinct tests for cross-sectional dependence used in Table 4 (Akın, 2019). In light of this, the results show that the independent cross-section null hypothesis is firmly dismissed for all variables, indicating that cross-sectional dependence exists. It implies that a disruption occurring in one of the MENA nations might have an economic ripple effect on the other economies. From an inference process, this result enables us to carry out tests and calculations in the subsequent stages of the empirical investigation that are more suitable (Henningsen & Henningsen, 2019).

Table 4. Cross-Section dependency tests

Variables	Breusch-Pagan LM Test/ Bias-Corrected Scaled LM Test/ Pesaran CD Test		
	LM	LM_{adj}	Pesaran CD
RE	103.68***	12.59***	11.43***
IM	219.00***	30.38***	12.491***
IC	417.62***	61.03***	20.418***
IF	58.96***	5.691***	3.095***
GVE	145.66***	19.06***	5.248***
GDP	416.72***	60.89***	20.196***
TRA	102.63***	12.42***	3.100***
MV	304.80***	43.62***	16.912***

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

Based on Table 5, given that the prob value suggests a 1% significant level in terms of common sample it ascertains the presence of cross-sectional dependence between the indicators evaluated in this study.

Table 5. Cross-sectional dependence (CSD) test for the common sample

Cross-sectional dependence (CSD) tests		
Test	T-stat	Prob.
Breusch-Pagan LM	217.0997***	0.0000
Pesaran scaled LM	30.25884***	0.0000
Pesaran CD	10.81569***	0.0000

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

The fact that cross-sectional dependency between the panels has been confirmed shows that conventional methods for testing the unit root are invalid. As a result, we used a second-generation unit root test (CIPS and CADF) to validate the data series' integration order. Results from Table 6 show that all variables are stationary at the first difference, which was supported by CADF. Whereas CIPS demonstrated stationarity for all the variables at the level and first difference. As a result, we may use the cointegration approach to validate the long-term association among factors since the integration order of all the variables is the same (first difference).

Table 6. The results of second-generation panel unit root tests

Variables	CIPS stats (Constant)		CADF stats (Constant)	
	Levels	First Difference	Levels	First Difference
RE	-2.245**	-5.243***	-1.367	-3.245***
IM	-2.897***	-4.329***	-2.213	-2.898***
IC	-2.941***	-3.963***	-2.723***	-3.453***
IF	-2.920***	-4.953***	-2.904***	-4.210***
GVE	-2.065***	-3.270*	-2.052	-2.257*
GDP	-2.422**	-3.524***	-2.061	-3.213***
TRA	-2.597***	-4.327***	-2.044	-2.896***
MV	-2.651****	-4.728***	-2.210**	-3.763***

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

Table 7 reports both the long-run and the short-run results of the PMG Ardl for the determinants of renewable energy consumption in MENA countries. Starting with the long-run estimates the findings reveal that energy importation and national income have a detrimental impact on renewable energy consumption. For instance, a 1% increase in energy importation and national income appear to decrease renewable energy consumption by 0.0006%, and 0.668% respectively. The outcome of energy importation is confronting the results found by Akarsu and Gümüşoğlu (2019). Both authors disclosed that energy importation has a positive influence on renewable energy consumption in lower and upper-regime countries. In contrast, indicators such as inflation, government expenditure, economic growth, and industrial sector performance uncovered to rise the renewable energy consumption in MENA countries. As an illustration, we observe that a 1% increase in IF, GVE, GDP, and MV contributes to 0.003%, 0.006%, 0.54%, and 0.34% growth in renewable energy consumption. These outcomes are consistent with Saibu and Omoju (2016). Both authors discovered the presence of a long-run relationship between renewable electricity consumption and GDP. Similarly, Lau et al. (2018) concluded that economic growth and foreign direct investment (FDI) are the major drivers for renewable electricity consumption. Interestingly, the variable trade disclosed an insignificant influence on renewable energy consumption. This result is totally different from a study conducted by Chen et al. (2021). The authors examined the determinants of renewable energy consumption in relation to democratic institutions. Their findings presented that increased trade openness leads to lower growth rates of renewable energy consumption in less democratic countries. Furthermore, the short-run estimates presented that all the variables have no prominent or inconsequential impact on the renewable energy consumption of the selected countries.

Table 7. Panel ARDL estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
		Long Run Equation		
IM	-0.0006***	0.0002	-2.7146	0.0081
IC	-0.6608***	0.1811	-3.6481	0.0005
IF	0.0039*	0.0022	1.7727	0.0799
GVE	0.0069***	0.0023	2.9715	0.0039
GDP	0.5404***	0.1917	2.8177	0.0060
TRA	-0.0017	0.0011	-1.5001	0.1373
MV	0.3421**	0.1327	2.5772	0.0117
		Short Run Equation		
COINTEQ01	-0.1685	0.1138	-1.4804	0.1425
D(IM)	-0.1692	0.1770	-0.9562	0.3417
D(IC)	-0.7847	0.6482	-1.2106	0.2294
D(IF)	-0.0079	0.0066	-1.1920	0.2366
D(GVE)	-0.0082	0.0097	-0.8484	0.3986
D(GDP)	1.0024	1.4633	0.6849	0.4952
D(TRA)	-0.0023	0.0053	-0.4380	0.6624
D(MV)	0.2744	0.7600	0.3611	0.7189
C	-0.3427	0.3050	-1.1235	0.2644
Mean dependent var	-0.0487	S.D. dependent var		0.7720
S.E. of regression	0.2152	Akaike info criterion		-2.2039
Sum squared resid	3.8909	Schwarz criterion		-0.8234
Log-likelihood	239.70	Hannan-Quinn criter.		-1.6431

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

The causal relationship between two indicators cannot be determined using the panel ARDL approach, despite the fact that it predicts the long-run elasticities. As a consequence, the Dumitrescu-Hurlin Panel Causality test was run as part of the current investigation with the goal of examining the causative link between the variables. What is more, due to the presence of cross-sectional dependence in the panel, Dumitrescu-Hurlin for causality is considered the most appropriate (Rahman, 2023). The findings are documented in Table 8. After observing the results, we perceive various unidirectional causality among the variables. For instance, we conclude the presence of one-way causality running from energy importation to renewable energy consumption, national income to renewable energy consumption, economic growth to renewable energy consumption, trade to renewable energy consumption, and, industrial sector performance to renewable energy consumption. Further, the model revealed no prominent causality between government expenditure and renewable energy consumption.

Table 8. Dumitrescu Hurlin for causality test

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.	Direction
IM does not homogeneously cause RE	4.95086***	2.59506	0.0095	Unidirectional
RE does not homogeneously cause IM	3.07841	0.75669	0.4492	
IC does not homogeneously cause RE	6.45399***	4.07083	0.0000	Unidirectional
RE does not homogeneously cause IC	3.67904	1.34639	0.1782	
IF does not homogeneously cause RE	2.04730	-0.25565	0.7982	Unidirectional
RE does not homogeneously cause IF	5.70957***	3.33995	0.0008	
GVE does not homogeneously cause RE	2.77851	0.46225	0.6439	No Causality
RE does not homogeneously cause GVE	2.88795	0.56970	0.5689	
TRA does not homogeneously cause RE	4.01591*	1.67712	0.0935	Unidirectional
RE does not homogeneously cause TRA	3.51492	1.18525	0.2359	
MV does not homogeneously cause RE	8.06870***	5.65614	0.0000	Unidirectional
RE does not homogeneously cause MV	3.90703	1.57023	0.1164	
GDP does not homogeneously cause RE	6.24925***	3.86981	0.0001	Unidirectional
RE does not homogeneously cause GDP	2.97637	0.65651	0.5115	

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

5. Conclusion

The signing of the Kyoto Protocol Agreement in 1997 significantly re-ignited global attention to using renewable energy sources. Since then, the production and use of renewable energy have markedly advanced worldwide. This in turn is accelerating social and economic development all around the world. Contrary to widespread assumption, wealthy nations are not the only ones that use renewable energy. Renewable energy is also swiftly gaining support from developing nations as an essential force behind societal and economic advancement. In this aspect, MENA countries are making significant progress toward developing renewable energy resources, despite their production and consumption being still in their infancy. The development of renewable energy resources as an alternative energy source has received significant attention from the MENA countries.

In addition to that MENA region contains top petroleum-producing countries such as Saudi Arabia, Iraq, Kuwait, Qatar, Algeria, Oman, and Egypt the fact of being top countries in petroleum output came with challenges such as shifting to more renewable energy sources and the partial disassociation from petrol due the climate change, and the pressure of environmental protection organizations that are urging the use of renewable energy sources more extensively.

Therefore, this study aimed to determine the factors that affect the consumption of renewable energy in the MENA region. In order to do this, the research makes use of panel data that covers the years 2000 to 2021 for seven chosen nations: Algeria, Morocco, Egypt, Iraq, United Arab Emirates, Qatar, and Saudi Arabia. Renewable energy consumption were taken into account as dependent variables. Additionally, the study identified a number of variables as possible drivers for renewable energy, including national income, inflation, government spending, GDP, trade, manufacturing, and value-added. To continue the investigation, a Panel ARDL approach and causality test are employed in hope of determining the long run and the causation direction between the variables.

Accordingly, the long-run estimates of the findings reveal that energy importation and national income have a detrimental impact on renewable energy consumption. National income and energy import can have a negative effect on renewable energy consumption for several reasons. For instance, renewable energy technologies are often more expensive to install and maintain compared to traditional fossil fuel-based energy sources. Higher national income means that consumers and businesses may be more likely to prioritize cost savings over environmental concerns, and may opt for cheaper non-renewable energy sources. Next, a country's energy infrastructure can heavily influence its ability to adopt and integrate renewable energy sources. Energy import can make non-renewable sources more readily available, while a higher national income may mean that the country has already invested heavily in existing energy infrastructure, making it more difficult and expensive to transition to renewable energy. Finally, governments often provide subsidies and incentives to encourage the adoption of renewable energy sources. However, higher national income may mean that consumers and businesses are less reliant on government incentives and more likely to prioritize economic benefits over environmental ones.

In contrast, indicators such as inflation, government expenditure, economic growth, and industrial sector performance uncovered to rise the renewable energy consumption in MENA countries. The fact behind the positive influence of these indicators is explained by the fact that Inflation can increase the cost of traditional energy sources, such as oil and gas. This can make renewable energy sources, such as solar and wind, more economically viable and attractive to consumers and businesses. Second, government spending on renewable energy infrastructure and subsidies can help to promote the adoption of renewable energy sources. This can increase the availability and accessibility of renewable energy and reduce the overall cost of transitioning to clean energy. Third, economic growth can lead to an increase in energy demand. As the demand for energy grows, there is a need for new sources of energy. Renewable energy can help to meet this demand while also reducing the reliance on traditional, finite energy sources. Last, the industrial sector is a major consumer of energy, and its performance can heavily influence energy demand. If the industrial sector is performing well, this can lead to an increase in energy consumption, including renewable energy, to meet the growing demand. Furthermore, the short-run estimates presented that all the variables have no prominent or inconsequential impact on the renewable energy consumption of the selected countries. In case of Dumitrescu Hurlin for causality test we concluded the presence of one-way causality running from energy importation to renewable energy consumption, national income to renewable energy consumption, economic growth to renewable energy consumption, trade to renewable energy consumption, and, industrial sector performance to renewable energy consumption

Based on the results there are several policy implications that governments can consider to promote the adoption of renewable energy sources in MENA countries. First, governments can develop policies that promote the adoption of renewable energy sources. This can include subsidies and incentives for renewable energy infrastructure development and adoption, as well as regulations that promote the use of renewable energy sources in various sectors. Second, governments can increase public awareness about the benefits of renewable energy sources and the impact of traditional energy sources on the environment. This can help to increase demand for renewable energy sources among consumers and businesses. Third, governments can support research and development of new renewable energy technologies that can be more efficient and cost-effective than existing technologies. This can help to make renewable energy sources more accessible and affordable for consumers and businesses. Fourth, governments can invest in improving energy infrastructure, including transmission and distribution networks, to support the integration of renewable energy sources into the existing energy system. Last but not least MENA countries can collaborate with international organizations to share best practices and knowledge about renewable energy adoption. This can help countries to learn from each other and accelerate the adoption of renewable energy sources.

Finally, the study will provide evidence to the MENA nations and the countries struggling to promote renewable energy consumption by identifying the factors that need to be prompted to increase renewable energy consumption and dissociate from non-renewable energy without compromising to achieve sustainable economic development.

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ETİK VE BİLİMSEL İLKELER SORUMLULUK BEYANI

Bu çalışmanın tüm hazırlanma süreçlerinde etik kurallara ve bilimsel atıf gösterme ilkelerine riayet edildiğini yazar beyan eder. Bu çalışma etik kurul izni gerektiren çalışma grubunda yer almamaktadır.

ARAŞTIRMACILARIN MAKALEYE KATKI ORANI BEYANI

1. yazar katkı oranı: %100