Energy consumption and economic growth relationship: Evidence from MENA countries using Panel Data Analysis

العلاقة بين استهلاك الطاقة والنمو الاقتصادي– حالة دول الشرق الأوسط وشمال افريقيا باستخدام تحليل البيانات الطولية

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Abstract:

This study examines the relationship between energy consumption (EC) and economic growth (GDP) for a sample of 14 MENA countries during the period 1980-2017. These countries are divided into two groups: Group of Energy Exporting Countries (OPEC countries). And a group of poor countries in terms of energy sources (the rest of the countries). by using recently developed panel co-integration techniques. We adopt a four-stage approach, consisting of panel unit root, panel co-integration, Granger causality and estimate the kuznets curve between the two variables.

The results showed that GDP and energy consumption move together in the long-run. By estimating these long-run relationships and testing for causality using panel co-integration techniques. We found bidirectional causality between energy consumption and economic growth.

Finally, we estimated the Kuznets curve between the two studied variables, as we found that the curve hypothesis is fulfilled in the case of the countries combined, and in the case of the energy-exporting countries (involved in the OPEC), While it is different for other countries.

Keywords: *Energy consumption; Economic growth; Panel data analysis; Kuznets curve; Middle East and North Africa.*

Jel Classification Codes :*C33; O13; Q32; Q43.*

ملخص:

تبحث هذه الدراسة في العلاقة بين استهلاك الطاقة والنمو الاقتصادي لعينة من 14 دولة في منطقة الشرق الأوسط وشمال إفريقيا خلال الفترة 1980-2017. تنقسم هذه الدول إلى مجموعتين: مجموعة الدول المصدرة للطاقة (دول الأوبك)، ومجموعة الدول الفقيرة من حيث مصادر الطاقة (باقي الدول). باستخدام تقنيات التكامل المشترك في حالة البيانات الطولية،واعتمدنا نهجا من أربع مراحل، اختبارات جذر الوحدة ، التكامل المشترك، واختبارات السببية وأخيرا تقدير منحنى كوزنيتس بين المتغيرين.

أظهرت النتائج أن الدخل الوطني واستهلاك الطاقة يتحركان معا في الأجل الطويل، من خلال تقدير هذه العلاقة طويلة الأجل واختبار السببية باستخدام تقنيات التكامل المشترك، وجدنا علاقة سببية ثنائية الاتجاه بين استهلاك الطاقة والنمو الاقتصادي.أخيرا، قمنا بتقدير منحنى كوزنتس بين المتغيرين المدروسين، حيث وجدنا أن فرضية المنحنى مستوفاة في حالة الدول مجتمعة، وفي حالة الدول المصدرة للطاقة (المنظمة إلى أوبك)، بينما هي مختلفة في حالة بقية الدول.

الكلمات المفتاحية: استهلاك الطاقة؛ نمو اقتصادي؛ نماذج البيانات الطولية؛ منحنى كوزنيتس؛ الشرق الأوسط وشمال افريقيا.

تصنيف جال:C33؛O13؛Q32؛Q43.

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Introduction:

Energy conservation is an important macroeconomic policy issue for many governments, including countries in the Middle East and North Africa. However, there is debate about the relationship between energy consumption, economic growth, and inconclusive outcomes. Studies on the relationship between energy consumption and economic growth (the relationship between energy and growth) are numerous, and several survey papers have been conducted in the global context over the years. First studies on the causal relationship between energy consumption and economic growth of Kraft & Kraft. who studied the data for the period 1947-1974, and found that only GDP for energy consumption is in one-way causation, and the results imply that implementing an energy conservation policy will not affect economic growth.

The topic of causal relationship between energy consumption and growth has been well-studied in the energy economics literature. Different studies have focused on different countries, time periods, proxy variables and different econometric methodologies have been used for energy consumption and growth relationship. The empirical outcomes of these studies have been varied and sometimes found to be conflicting. The results seem to be different on the direction of causality and its long-term versus short-term impact on energy policy. The policy implications of these relationships can be significant depending upon what kind of causal relationship exists. The previous literature that focuses on the causal relationship between ‘‘energy consumption and economic growth’’ and ‘‘electricity consumption and economic growth’’ is not conclusive to provide policy recommendation that can be applied across countries.

For example, the existence of a unidirectional causality running from energy consumption to economic growth tends to support the hypothesis that energy plays a crucial role in economic growth. The presence of such a causal relationship implies that economic growth is dependent on energy consumption and no access, or limited access, to energy can restrain economic growth and threaten the well-being of current and future generations. Under these conditions, it is essential to integrate into national and regional development programmes, innovative approaches to improve access to affordable, modern and clean energy, including household access to electricity from renewable energy technologies, for all populations and productive sectors.

I-Literature Review:

Energy is the lifeblood of the global economy, as it is an essential input for the production of nearly all goods and services in the modern global economy. as energy is the input for almost all production of goods and services. It is known that interruptions in the supply of many energy sources have a major impact as they can severely affect the economies of almost all countries. Additionally, stable and low energy prices are known to help stimulate the growth rate of any economy. This is because lower energy prices lead to more disposable income for consumers and lower costs for companies. Improved corporate profit margins and higher consumer disposable income provide incentives for accelerated growth rates (Abosedra, Shahbaz, & Sbia, 2015).

It is said that energy use depends on the stage of development of the economy. Since the country is growing at a faster rate, it may require more energy. Energy use is required for industrialization, urbanization, and transportation which helps the growth process. Therefore, there can be a two-way causal relationship between energy use and economic growth (Mahalik & Hrushikesh, 2014, p. 140). Also, governments have become interested in studying the relationship between energy consumption and gross domestic product due to the international goal of curbing global temperature increase to a maximum of 2 degrees Celsius in the context of global warming. To achieve this goal, it has become imperative to assess the impacts of policies promoting energy conservation and efficiency on national GDP and economic growth. According to the International Energy

Agency(EIA, 2019), "80% of emissions from the energy sector planned for 2020 and 40% of carbon dioxide emissions from OECD countries have already been reached" (Campo & Sarmient, 2013).

The role of energy is often ignored in the prevailing empirical literature on the determinants of economic growth. There are many models where resources relate to production inputs in the sub-domain of environmental and resource economics, but most of them assume good substitution potential between resources and other inputs (i.e., the Cobb-Douglas production function where substitution elasticity is the same) and do not focus on the potential role of energy in enabling growth (David I., Paul J., & Stephan B., 2017). The prevailing theory of economic growth also gives little or no attention to the role of energy or other natural resources in promoting or enabling economic growth. The exception was the intense discussions of a productivity slowdown in the wake of the oil crises of the 1970s. Much of the related literature is out of the mainstream in what has come to be known as environmental economics (David I. & Cutler J., 2004).

If energy constitutes a relatively small part of the total cost of production or is not an initial input when compared to other production inputs, then the disruption in the purchase of energy or its increase in its price will not have a major impact on the economy. Conversely, if energy is a very important input in the production process or it is among the basic human needs, the potential problems in its supply or exorbitant energy prices will cause serious problems in both production and the daily life of consumers. In this sense, identifying and examining the factors that enhance or reduce the link between energy use and economic activities is of critical importance for achieving sustainable growth (Ömer & Metin, 2017).

It is clear that appropriate policy decisions differ according to the type of relationship. For example, if energy consumption causes economic growth, energy reduction policies may negatively affect the economy, while if there is no causal relationship between energy and GDP, then energy conservation and economic growth can be practiced together (Mukhtarov, Jeyhun I., & Vüqar, 2017).

After the oil crises of the 1970s, the relationship between economic growth and energy consumption became a common research topic of theoretical and empirical studies, as well as one of the major issues of debate in the economics literature. Recently, many studies have investigated the causal relationship between energy consumption and economic growth. This issue is important because energy drives the wheels of economic growth as it is a major factor in production, along with capital and labor. In addition, the higher the per capita GDP, the higher the energy demands. The pioneering study by J. Kraft and A. Kraft 1978 confirms this by providing evidence for a one-way causal relationship from GNP to energy use in the United States during the period 1947-1974 (Abosedra, Shahbaz, & Sbia, 2015, p. 1). Hence, (Uri) put forward a suggestion that scarcity of resources has affected economic growth in the United States, and that fluctuations in crude oil prices have affected employment as well as the unemployment rate (Chien-Chiang & Chun-Ping, 2007).

In the three decades since Kraft and Kraft's 1978 basic study, economists and other researchers have studied the relationship between energy consumption and GDP from different perspectives and using various methodologies. Their methods ranged from descriptive time-series analysis to applications of co-integration with panel data (Campo & Sarmient, 2013).

Next, a large number of empirical studies have analyzed the relationship between energy consumption and economic growth in past years (see, for example (Kasperowicz & Štreimikien, 2016), Akarca and Long, 1980; Eroland Yu, 1987; Asafu-Adjaye, 2000; Ghali and El-Sakka, 2004; Soytas and Sari, 2006; Climent and Pardo, 2007; Sari and Soytas, 2007; Odhiambo, 2009; Tsani, 2010; among others) investigated the relationship between energy consumption and economic growth in different countries or regions using different methods for different periods (Adhikari & Chen, 2012).

However, the studies of other American scientists are not the same. Using time-series data, Akarca and Long did not reach the same conclusion. Yu and Hwang, based on the disbursed sample data, concluded that there was no causal relationship between energy consumption and economic growth. Hanison has shown that the relationship between energy consumption and economic growth is also different due to different periods (Wei-wei, 2012). On the other hand, Akarca and Long (1980) showed no evidence of a causal relationship between energy consumption and GDP when the investigation period is shortened by two years. They concluded that the results of Kraft and Kraft (1978) are false. Erol and Yu 1987 used the Sims and Granger causation tests and found a one-way causal relationship from energy consumption to income for West Germany while causation was bidirectional for Italy and Japan, and there is no evidence of a causal relationship in the United Kingdom, Canada, and France (Altinaya & Karagol, 2004).

In recent years, the debate about the environmental consequences of increased energy consumption and the use of alternative energy sources has gained more and more attention in developed and developing countries. At the same time, the recent decline in crude oil prices and the rising costs of renewables, especially for developing countries, indicate that the relationship between energy consumption, energy prices, and economic growth opportunities remains of great importance (Carfora, RosariaVeg, & Giuseppe, January 2019).

Experimental results carried out by (Fei Li, Suocheng Dong, XueLia, Quanxi Liang, Wangzhou Yang) in 30 provinces in China from 1985 to 2007, show that there is a positive and complementary long-term relationship between per capita GDP. Real and power consumption variables. In the long term, a 1% increase in real GDP per capita increases energy consumption by (0.48-0.50%) (Fei, Suocheng, Xue, & Quanxi, 2011).

The experimental model of (Sania Ashraf, T Raja Sekar, Jaya Abraham) of nearly 44 countries around the world found that the high use of energy improves the economic situation of the country, but at the expense of environmental pollution -carbon dioxide emissions- (Ashraf, Sekar, & Abraham, 2020). For example, if concentrations of carbon dioxide in the atmosphere (CO2) and other greenhouse gases (GHGs) are left in the atmosphere, then global temperatures are expected to rise by about 3-4° C by the end of the century. Changes in temperature of this magnitude are large by historical standards and pose significant risks. Outdoor air pollution, mainly caused by fossil fuel combustion, causes more than 3 million premature deaths annually worldwide, which costs about 1% of the GDP of the United States and about 4% of China (Heine , Lis, Shanjun, & Parry, 2014).

Ozturk (2010), Squalli (2007), and Magazzino (2011) offer four hypotheses about the trend of causation between energy consumption and GDP (Campo & Sarmient, 2013). The first is the neutrality hypothesis, which states that there is no causal relationship (in either direction) between these two variables. The second is the conservation hypothesis, which states that there is evidence of a one-way causal relationship from GDP growth to energy consumption. Under the third hypothesis, which is known as the growth hypothesis, energy consumption drives GDP growth. The fourth hypothesis is the feedback hypothesis, which indicates a two-way causal relationship between energy consumption and GDP growth (Ozturk, 2010).

Through the above, it can be said that some empirical studies have been conducted using different approaches, periods, and alternative variables about the causal relationship between energy consumption and economic growth in different countries, but the evidence from empirical research remains mixed and controversial in terms of the direction of causation and the strength of the effect of the use of Energy to economic growth. Even when the relationship is supported by an econometric approach, it is usually weak and has very low explanatory and predictive power (Ouedraogo, 2013). The study of the relationship between energy consumption and economic growth, which is often based on the direction of the causal relationship between energy consumption and economic growth. If one-way causation is found to extend from energy

II-Data and methodology:

Co-integration analysis is the appropriate technique to investigate the long-run relationship between energy consumption and economic growth (Gross Domestic Product GDP). In the panel context, the causality consists of four steps. First, panel unit root tests for the series are undertaken. Second, if they are integrated at order one I (1), co-integration tests are employed. Third, if the series are co-integrated, this means that there is A long-run relationship .and that implies that there is a causal relationship in at least one direction. Then a Panel model of a quadratic equation is established to examine the Kuznets curve hypothesis using the panel Dynamic Ordinary Least Square (DOLS) methods.

Data used in this analysis are annual time series on Gross Domestic Product per capita of the selected countries is at constant prices in US dollars and purchasing power parity (PPPs) (hereafter referred to as RGDP); per capita energy consumption in kilograms of oil equivalent (referred to as EC) for the 14 MENA countries for the period 1980–2017. These countries are: Algeria (DZA), Tunisia (TUN), Morocco (MAR), Egypt (EGY), Libya (LBY), Lebanon (LBN), Jordan (JOR), Iraq (IRQ), Bahrain (BHR), Saudi (SAU), United Arab Emirates (ARE), Sultanate of Oman (OMN), Kuwait (KWT), Qatar (QAT). GDP and EC data are obtained from the World Development Index of the World Bank (DataBank, 2020). All variables used in the study are in natural logarithm form.

II-1- Panel unit root tests:

Panel unit root tests are used to examine the degree of integration between GDP and energy consumption. Panel unit root tests have been suggested as an alternative test for examining the causal relationship between energy consumption and economic growth in a panel framework. Indeed, panel unit root tests are becoming popular because of their ability to capture the country-specific effects as well as allowing for heterogeneity in the direction and magnitude of the parameters.

To assess the stationarity properties of the variables used, this study utilises four different panel unit root tests including Levin, Lin and Chu (hereafter referred to as LLC) see (BALTAGI & KAO, 2000, pp. 11-14) ; Im, Pesaran, and Shin see (Christophe & Mignon, 2007) (IPS, 2003), (hereafter referred to as IPS); Breitung 2001 (HLOUSKOVA & WAGNER, 2005)and Hadri (Christophe & Mignon, 2007).

Table 01. Descriptive statistics of included variables

Variables	Mean	Standard Deviation	Minimum	Maximum
LRGDP	10.00588	1.026382	8.095879	12.06102
LEC	7.741091	1.211260	5.578822	9.996952

Table 02.panel unit root test results

Test	Level	LRGD		LEC	
Breit	Level	1.15872	0.8767	-0.98137	0.1632
	1st difference	-4.87217*	0.0000	-8.75456*	0.0000
LLC	Level	-2.82438*	0.0024	-3.81930*	0.0001
IPS	Level	-3.92904*	0.0000	-3.06625*	0.0011
Hadri	Level	5.49430*	0.0000	5.92488*	0.0000
decision		I(0)		I(0)	

* Indicates statistical significance at 1%

The results of the LLC, IPS, Hadri, panel unit root tests for the two variables LRGDP, LEC are shown in Table 02. The unit root statistics reported are for the level and first differenced series of these variables. For the variables in level form, the null hypothesis of a unit root cannot be rejected for the Breitung test,while the IPS and LLC and Hadri tests reject the null hypothesis at the 1% significance level for all variables. Therefore, it is safe to conclude that all variables are stationary and integrated of order zero or I(0).

II-2- Panel co-integration results:

For the Co-integration between the two variables, we use two tests, the Kao test (Mei-Yuan, 2013, p. 11)(hwa Kao & Chiang, 2000), and the Pedroni test (Pedroni P. , 2000)(Baltagi, 2005). The results are shown in the following two tables:

Table 03. Kao Co-integration Test Resuls

Kao Residual Cointegration Test		
Series: LEC LRGDP		
	t-Statistic	Prob.
ADF	-2.185602**	0.0144
Residual variance	0.014364	
HAC variance	0.011168	

Notes: The ADF is the residual-based ADF statistic (Kao., 1999) ,** indicate that the estimated parameters are significant at 5% levels.

This table reports the results of Kao's (1999) residual panel cointegration tests, which reject the null hypothesis of no cointegration between energy consumption and real GDP at the 05% levels of significance. This means that there is a long-term relationship between the two variables studied.

Table 04. Pedroni Co-integration Test Results

Pedroni Residual Cointegration Test				
Series: LEC LRGDP				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	2.651522**	0.0040	1.162303	0.1226
Panel rho-Statistic	-2.954815**	0.0016	-2.102263	0.0178
Panel PP-Statistic	-3.310811**	0.0005	-3.384834	0.0004
Panel ADF-Statistic	-3.365986**	0.0004	-3.075734	0.0010
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	-2.205037**	0.0137		
Group PP-Statistic	-4.509608**	0.0000		
Group ADF-Statistic	-4.159921**	0.0000		

Notes: The null hypothesis is that the variables are not cointegrated. Under the null hypothesis, all the statistics are distributed as normal. The finite sample distribution for the seven statistics has been tabulated in Pedroni (Pedroni., 2004)

The last table reports the within and between dimension results of the panel co-integration tests. These results suggest that the null hypothesis of no co-integration was rejected at a 5% significance level for all tests. Therefore, there is a long-run relationship between energy consumption and GDP for our panel of countries.

These results indicate that there is a long-term equilibrium relationship between energy consumption and per capita income (econo

mic growth), meaning that they move closer together overtime to reach the equilibrium point, although it may contain random (unstable) time trends.

II-3- Granger causality results:

Having established that economic growth is cointegrated in the longrun with energy consumption, This means that there is a causal relationship in at least one direction. the next step is to examine the causality between these variables. For this purpose, we will use two tests, the Granger Causality (Eviews, 2015) Test and the DumitrescuHurlin (Hurlin, 2007)(Dumitrescu & Hurlin, 2011)(Eviews, 2015) Panel Causality Tests. Tables 06 and table 07 report the results of the Granger-causality tests for the panel dataset. The optimal lag structure of 2 years is chosen using the Akaike and the Schwarz Information Criterions.

Table 05. Panel Granger Causality Tests Results

Pairwise Granger Causality Tests			
Null Hypothesis:	Obs	F-Statistic	Prob.
LRGDP does not Granger Cause LEC	481	5.94051**	0.0028
LEC does not Granger Cause LRGDP		3.48051**	0.0316

** Indicates that the estimated parameters are significant at 5% level.

Table 06. Panel DumitrescuHurlin Causality Tests Results

Pairwise DumitrescuHurlin Panel Causality Tests			
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
LRGDP does not homogeneously cause LEC	3.82976	2.55033**	0.0108
LEC does not homogeneously cause LRGDP	5.94067	5.80508**	6.E-09

** Indicates that the estimated parameters are significant at 5% level.

The results shown in the two previous tables show that there is a bidirectional causality relationship.Between the two variables.

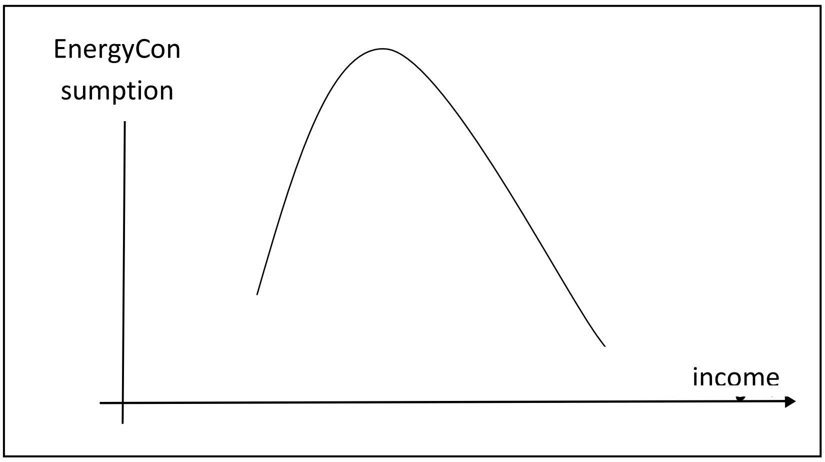
Overall, the relationship between energy consumption and economic growth is characterised by unidirectional causality running from real GDP to energy consumption in the shortrun. In the long-run, there is reverse causality, running from energy consumption to GDP: an increase in per capita energy consumption leads to an increase in real GDP.

These results are related to the studied sample, which is a group of developing countries. A bidirectional causality relationship turns out to make sense. Because the increase in economic growth is driven by an increase in energy consumption. The rise in energy consumption is driven by an increase in per capita income (economic growth in other words).

II-4- Estimation of Kuznets curve model (relationship between energy consumption and economic growth):

Finally, after finding the bidirectional causal relationship between energy consumption and economic growth, we can test the hypothesis of the environmental Kuznets curve. a peak in primary energy sources as income grows. This relationship is represented by quadratic polynomials in per capita GDP, which is a polynomial of lower degree which enables us to capture peak energy demand (i.e. constant saturation point) and inflection point where income elasticity of energy demand is highest. This miniature approach to structural models has been favored as being more flexible (i.e., imposing fewer assumptions), but it requires a sufficiently long history and wide cross-sectional diversity (Bogmans, Kiyasseh, & Matsumoto, 2020).

Figure 1. The relationship between energy consumption and income according to the Kuznets curve approach



Source: Authors

II.4.1. Estimation method:

Although OLS estimators of the cointegrated vectors are super convergents, their distribution is asymptotically biased and depends on nuisance parameters associated with the presence of serial correlation in the data. Such problems, existing in the time series case, also arise for the panel data and tend to be more marked even in the presence of heterogeneity.

To carry out tests on the cointegrated vectors, it is consequently necessary to use methods of effective estimation. Various techniques exist, such as Fully Modified Ordinary Least Squares (FMOLS) initially suggested by Philips and Hansen (Phillips & Hansen, 1990)or the method of Dynamic Ordinary Least Squares (DOLS) of Saikkonen(Saikkonen, 1991) and Stock and Watson (Stock & Watson, 1993). In the case of panel data, Kao and Chiang (Stock & Watson, 1993) showed that these two techniques led to normally distributed estimators, which means that both OLS and Fully Modified OLS (FMOLS) exhibit small sample bias and that the DOLS estimator appears to outperform both estimators. Similar results are got by Phillips and Moon (Phillips & Moon, 1999) and Pedroni(Pedroni P. , 2001) for the method FMOLS (Farhani, Shahbaz, & el Hed, 2013).

Among the most important findings of Kao and Chiang 2001, we mention:(Chihwa & Min-Hsien, 2000)

- The least-squares estimator has a large bias in the case of small samples.

- The FMOLS estimator was not the best overall compared to the OLS estimator.
- The FMOLS estimator is further complicated by the correlation of the correction limit based on the OLS estimator, which may be very biased in the case of limited samples in the panel data, and furthermore, the nonparametric correction failure of FMOLS in the case of the panel data may be significant.
- This indicates that the DOLS estimator may be more efficient and effective than the OLS and FMOLS capabilities in the case of estimating cointegrated vector models in the panel data.

The vector of parameters are estimated by the DOLS method assuming the following equation:

$$W_{it} = \alpha_i + \beta_i X_{it} + \varepsilon_{it} \qquad \forall t = 1....T \qquad \forall i = 1....N......(1)$$

and he proposes that W_{it} and X_{it}, are cointegrated with slopes β_i, which β_i may or may not be homogeneous across i. So we will obtain the following equation:

$$W_{it} = \alpha_i + \beta_i X_{it} + \sum_{k=-k_i}^{k_i} \gamma_{i,k} \Delta X_{i,t-k} + \varepsilon_{it} \qquad \forall t = 1.....T \qquad \forall i = 1.....N.......(2)$$

This technique consists to include advanced and delayed values of $\Delta X_{i,t-k}$ in (Eq. 1) in the cointegrated relationship, to eliminate the correlation between regressors and error terms. The panel DOLS estimator is defined as:

$$\hat{\beta}^*_{dols} = \frac{1}{N} \sum_{i=1}^{N} \left[\left(\sum_{t=1}^{T} Z_{it} Z'_{it} \right)^{-1} \left(\sum_{t=1}^{T} Z_{it} \tilde{W}_{it} \right) \right]_i$$

Where:

$$Z_{it} = \left[X_{it} - \overline{X}, \Delta X_{i,t-1}, ..., \Delta X_{i,t-k} \right]$$

And

$$\tilde{W}_{it} = W_{it} - \overline{W_i}$$

Given that the assumed Kuznets curve is a parabola with its peak to the top, its function is in the form of a second degree polynomial of the shape:

Y=aX2+bX+c………………….(3)

Where Y is the dependent variable (energy consumption in our case), and X is the independent variable (per capita income).

According to the mathematical form of the function previously referred to in the conceptual aspect of the Kuznets curve, the references to the parameters a, b, c should be as follows:

for the parameter (a) we expect it to be negative, since the limit of when the independent variable translates to infinity (±∞) must be Be -∞.

for the parameter (b) we expect it to be positive, in order for the value of the dependent variable at the peak to be positive.

for the parameter (c) we expect it to be positive because even in the absence of income (it does not exist at the macro level), the energy consumption is not negligible.

II.4.2. Estimation results

Table 07 provides the results of the country-by-country and panel DOLS tests. All variables are expressed in natural logarithms. The estimated coefficients from the long-run cointegration relationship can be interpreted as long-run elasticities. In all cases, the parameters are quite significant at the 5% level of significance. From thethe OLS estimator, which may be very biased in the case of limited samples in the panel data, and furthermore, the nonparametric correction failure of FMOLS in the case of the panel data may be significant sign of the parameter, the results show that there are inverse U-shaped relationships between energy consumption and per capita real GDP for five MENA countries, namely: Bahrain, Kuwait, Libanon, Qatar and Tunisia. As for the rest of the countries, the relationship was inverse, i.e. in the form of U, and the behavior of the function or dependent variable in the case of countries combined as a whole expresses the Kuznets curve.

Table 07.DOLS results at the country level

Countries	C	LRGDP^2	LRGDP
ARE	-7.202777	1.018952	-23.15971
BHR	-6.834419	-3.966763	84.27287
DZA	-8.533464	10.58421	-196.8353
EGY	-8.640996	3.765265	-67.21777
IRQ	-8.437424	0.187335	-3.453303
JOR	-8.233730	0.199928	-3.583340
KWT	-7.187047	-1.185456	25.84899
LBN	-8.394956	-0.059311	1.132009
LBY	-7.863313	0.472051	-9.336098
MAR	-8.742365	2.422362	-40.58551
OMN	-7.895103	8.907271	-187.2199
QAT	-6.662173	-0.256587	6.230796
SAU	-7.626044	1.034219	-21.95773
TUN	-8.446736	-0.126752	2.377763
Panel Equation		**-0.1014****	**2.5916****

<u>Model 01</u>: A model of the MENA countries combined

$$LEC = -0.1014*LRGDP^2 + 2.5916*LRGDP$$

As for the results obtained by country, and according to the model that we have in hand, energy consumption is a function of income, and therefore the change in energy consumption changes according to income elasticity (which is a function of income also because the model is a second-order equation). so we find that the income elasticity of the State of Bahrain is equal to (84.27-2 * 3.96LY) i.e. (84.27-7.92Lrgdp_BHR). The energy consumption reaches the peak of the curve at the point with coordinates (Lrgdp_BHR = 10.64) and (LEC_BHR = 441.48).

In the same way, the income elasticity of the State of Kuwait is equal to (25.84-2.37Lrgdp_KWT). and the energy consumption reaches the peak of the curve at the point with the coordinates (Lrgdp_KWT = 10.90) and (LEC_KWT = 134.27). and so for the rest of the countries.

As for the aggregate model (Panel data model), the income elasticity is (2.59-0.20Lrgdp_), and energy consumption reaches the peak of the curve at the point with coordinates (Lrgdp_ = 12.95) and (LEC_ = 16.76).

For a more detailed analysis, we consider the separation between countries that have large energy resources (represented by the MENA countries that belong to the Organization of Petroleum Exporting Countries OPEC). and the countries that do not have large energy resources or at least do not export these resources, which are the rest of the countries. and we proceed in this analysis That countries that have large energy resources do not care about energy efficiency. and therefore they are not interested in achieving energy efficiency or rationalizing its consumption. and on the contrary for other countries.

By separating these countries into the two aforementioned groups, we obtain the following two models.

Model 02: The model of the MENA countries outside of the OPEC

$$0.472*LGDPNOPEC^2+LECNOPEC = -7.678*LGDPNOPEC$$

We found in the model that the curve is U-shaped, i.e. the inverse of the Kuznets curve. which can be explained by the fact that energy consumption decreases in the first stage of the curve, that is, there is an inverse relationship between energy consumption and income (economic growth), which indicates that these countries seek to reduce or Rationalization of energy consumption (a scarce resource available through import), and in the second stage of the curve, that is, after reaching a certain level of income, energy consumption becomes increased with the increase in income, which indicates the existence of flexibility in the provision of energy resources more and easier.

Model 03: The model of the MENA countries involved in OPEC

$$LCO2OPEC = 1.034*LRGDPOPEC -0.021*LRGDPOPEC^2$$

This model corresponds to the shape of the Kuznets curve, or inverted U (such as the total model of a group of sample countries). Noting that these countries have large quantities of energy resources, which facilitates the process of obtaining them and thus increasing their consumption. In other words: in the first stage of the curve (a direct relationship), that is, as income increases, energy consumption increases (an increase in energy infrastructure, an increase in the volume of investments, an increase in the consumption of the household sector in particular ...). At a certain point in the income (the inflection point of the curve), energy consumption begins to decrease, which is the second stage of the curve. where the relationship becomes inverse, which can be explained by paying more attention to energy efficiency and rationalizing its consumption while encouraging energy exports instead of consuming it locally (as countries Exporter of energy resources).

Conclusion:

In this paper, we examined the extent to which the environmental Kuznets curve hypothesis met the relationship between per capita energy consumption and the per capita income variable. On a group of countries in the Middle East and North Africa, which are diverse countries between countries rich in depleted energy resources (countries involved in OPEC), and countries with poor energy sources or at least not exporters of depleted energy resources. Using the Panel data, we estimated the environmental Kuznets curve model. The results, as we have seen previously, have three dimensions.

• The overall model for the countries of the Middle East and North Africa combined. It is a model that represents an inverted U-shaped parabolic curve, contains the input variable as an interpreted variable, and in which the signals of the estimated parameters matched the signals of the hypothesis parameters. That is, energy consumption is a function of income.

• The partial model for the enamel countries that belong to the OPEC organization, which is similar to the first combined model, which means that energy consumption knows two contradictory stages, the first stage in which energy consumption is in a direct relationship with income, that is, consumption increases with increasing income (income exploitation In developing the infrastructure and increasing the utilization of energy installations ...), and a second stage defines an inverse relationship between energy consumption and income, which indicates reaching the stage of interest in energy efficiency and encouraging the optimal use of energy resources, with an interest in exporting more energy resources for more Hard currency.

• The partial model of the enamel countries outside OPEC, which is an opposite model to the previous two models, and the signal of the parameters estimated in this model is opposite to the signals of the hypothesis parameters. What indicates the scarcity of these energy resources in these countries, including their low consumption, and this is their scarcity, even partially for these energy resources, and a second stage when income reaches a certain degree, where energy consumption becomes increased with the increase in income, which means access to energy resources and from Then increase its consumption more easily with the availability of more income.

The difference between the studied sample countries through the results obtained lies in the energy systems followed in these countries, as almost all of them depend on a high percentage of depleted energy resources, and here lies the difference between the countries exporting these resources (which do not pay much attention to the consumption pattern on the one hand, and try Maximizing production, on the other hand, to increase exports and then incomes), and the rest of the countries (which suffer from a scarcity of energy resources as they are relatively scarce primary resources, and therefore these countries take into account energy efficiency and try to rationalize their consumption, hence energy consumption was affected by the income variable).

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