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# Modeling Economic Growth and Energy Consumption in Arab Countries: Cointegration and Causality Analysis

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**ABSTRACT:** This paper examines the relationship between energy consumption and real economic growth in 17 Arab countries: Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen. It uses an Auto Regressive Distributed Lag (ARDL) model to determine this econometric relationship using data during 1980-2011. After testing for unit root and cointegration, it identifies Granger causality between energy consumption and real economic growth. The analysis allowed for the verification of the four hypotheses that have been discussed widely in economic literature: Neutrality, Conservation, Growth, and Feedback hypotheses. Empirical findings support neutrality hypothesis in 16 out of 17 Arab countries. These findings, of no causality from economic growth to energy consumption and the other way round, imply that energy conservation will not have a significant impact on economic growth and economic growth will have insignificant effect on changes in energy consumption. They also suggest including other more important variables in the determination of economic growth, such as labor and capital.

**Keywords:** economic growth; energy consumption; ARDL model; Granger causality; Arab countries.
**JEL Classifications:** C33; O4; O13; Q43

## 1. Introduction

The analysis of links between economic growth and energy consumption was addressed by numerous research studies. Four hypotheses regarding this link can be found in the literature dealing with this topic: the growth hypothesis, the conservation hypothesis, the feedback hypothesis and the neutrality hypothesis. The growth hypothesis assumes that there are countries in which the growth of energy consumption is an important element of their economic development. The growth hypothesis is based on unidirectional causality running from energy consumption to economic growth. The conservation hypothesis claims that the changes in energy consumption stem from the changes in economic activity. The feedback hypothesis assumes that there are countries with bi-directional Granger causality between energy consumption and economic growth. The neutrality hypothesis states that there are countries in which GDP does not depend on energy consumption and vice versa.

This paper examines the relationship between energy consumption and economic growth in 17 Arab countries. We applied the Granger's causality approach which allows for examination of existence and direction of effect between economic growth and energy consumption. The paper contributes to the existing literature because the analysis focuses on Arab countries. Most of them have not been studied, from this angle, before.

## 2. Review of Literature

Existing literature offers a wide range of models that explored the relationship between energy consumption and economic growth, or what has been known as energy-growth nexus. These models assumed and tested four hypotheses:

(1) Neutrality hypothesis: This hypothesis assumes no causality between energy consumption and economic growth. Its implication is that energy conservation will not lead to economic growth and economic growth will not stimulate energy consumption. The neutrality hypothesis is supported by many recent studies including Stern & Enflo (2013), Ozturk & Acaravci (2011), Ozturk & Acaravci (2010) and Warr & Ayres (2010).

(2) Conservation hypothesis: This hypothesis postulates that a one-way directional causality runs from GDP to energy consumption. This implies that energy conservation policies may be implemented with little or no adverse effects on economic growth. However, it is possible that a growing economy constrained by political, infrastructural, or mismanagement of resources could generate inefficiencies and the reduction in the demand for goods and services, including energy consumption. The running causality from GDP to energy consumption was recently demonstrated by Baranzini et al. (2013), Damette & Seghir (2013), Ouedraogo (2013), Azlina & Mustapha (2012), Haghnejad & Dehnavi (2012), Adom (2011), Abbasian, Nazary & Nasrindoost (2010), Jamil & Ahmad (2010) and many other studies.

(3) Growth hypothesis: This hypothesis supports a uni-directional causality running from energy consumption to economic growth. The implication is that restrictions on the use of energy may adversely affect economic growth while increases in energy consumption may contribute to economic growth. A number of recent studies, including Damette & Seghir (2013), Javid, Javid & Awan (2013), Ouedraogo (2013), Solarin & Shahbaz (2013), Acaravci & Ozturk (2013), Haghnejad & Dehnavi (2012), Shahiduzzaman & Alam (2012), Kouakou (2011), Mazbahul & Nazrul (2011), Chandran et al. (2010), Chang (2010), Odhiambo (2010), Lorde, Waithe & Francis (2010), Yoo & Lee (2010) and many others, has demonstrated this hypothesis.

(4) Feedback hypothesis: Feedback hypothesis assumes a bi-directional causality between energy consumption and economic growth. It implies that energy conservation policy will adversely affect the economic output, while an increase in the economic output will increase the level of energy consumption. This hypothesis was demonstrated by Belaid & Abderrahmani (2013), Hu & Lin (2013), Tang & Tan (2013), Shahbaz & Lean (2012), Zhang & Yang (2013), Kouakou (2011), Ouédraogo (2010) and many others.

As Karanfil (2009), Ozturk (2010) and Payne (2010) demonstrated in their surveys of empirical literature devoted to this issue, the relations between economic growth and energy consumption are ambiguous and the differences in the results of the surveyed studies can be attributed to different econometric approaches, differently specified time frames and different sets of variables used.

Historically, these models went through four phases: In the first phase, the models were based on Vector Auto Regressive (VAR) methodology, such as Kraft and Kraft (1978) and did not carry out any investigation for the existence of unit root in the variables of the model. In the second phase these studies accounted for non-stationarity and applied Engle-Granger two-step procedure to test pairs of variables for cointegrating relationships. The third phase involved studies that used multivariate estimators, such as Johansen (1991), in which they allowed for more than two variables in cointegration relationship and for analyzing causality. In the fourth phase, studies were based on testing for unit roots, cointegration and Granger, or other types of, causality. The results of these models reached fairly inconclusive and, sometimes, controversial results concerning the exact nature and direction of the relationship between energy consumption and economic growth. Potential reasons for the differences in the results of these studies could be attributed to the degree of availability of data, type of analysis, the time periods examined, the econometric approaches and the variables included in the estimations, level of economic growth, and method of estimation. This gives rise for further research to guide economic theories and plans to generate economic development.

In spite of a substantial number of studies concerning relations between energy consumption and economic growth for several countries, few studies analyzed data for some Arab countries. In a recent meta analysis of the nexus between electricity consumption and economic growth, Bouoiyour et al. (2014) found that the conservation hypothesis is widely associated to American and European countries. However, conservative policies are likely to have an adverse effect on the economic growth in Asian and MENA countries.

Few studies explored energy-growth nexus for group countries. Examples of these studies that addressed MENA countries are Omri (2013) and Al-Mulali (2011). The latter examined the impact of oil consumption on the economic growth of the MENA countries during the period 1980–2009. Based on the cointegration test results, it was found that oil consumption has a long run relationship with economic growth. Moreover, there is also a bi-directional Granger causality between oil consumption and economic growth in both the short run and the long run. Ozturk and Acaravci (2011) investigated the relationship between energy consumption and growth rate in selected MENA countries using cointegration analysis and Granger causality test. The results show that there is no cointegration and causal link between the electricity consumption and the economic growth in Morocco and Syria. However, the cointegration and causal relationship is found for Egypt, Oman and Saudi Arabia. Intuitively, they argue that the energy conservation policy of MENA countries can have a no powerful impact on economic growth. Studies that considered Gulf Cooperation Council (GCC) include Al-Iriani (2006) which investigated the causality relationship between GDP and energy consumption in the six countries of the GCC. Empirical results indicate a unidirectional causality running from GDP to energy consumption. Evidence shows no support for the hypothesis that energy consumption is the source of GDP growth. Middle East countries including Oil Exporting countries were also a subject for further examination of energy-growth nexus. Examples of these studies include Damette and Seghir (2013), Mehrara (2007), Ozcan (2013), and Squalli (2007).

Other studies concentrated on individual Arab countries. For example, Eddrief-cherfi and Kourbali (2014) investigated the energy consumption-growth nexus in Algeria. The causal relationship between the logarithm of per capita energy consumption and the logarithm of per capita during the 1965-2008 is examined using the threshold cointegration and Granger causality tests. The estimation results indicate that there is a uni-directional causality running from GDP to energy consumption, but not vice versa. The research results strongly support the neoclassical perspective that energy consumption is not a limiting factor to economic growth. Bélaïd and Abderrahmani (2013) also analyzed the causal relationship between electricity consumption, Brent oil price and economic growth for Algeria during 1971–2010. The study used a multivariate cointegration approach and finds no evidence for neutrality hypotheses while there is evidence of short-run and a strong long-run bi-directional causal relationship between electricity consumption and real GDP in Algeria. Bouoiyour and Selmi (2013), using causality tests supported a conservation hypothesis in Morocco and Oman and growth hypothesis in Syria. Fuinhas and Marques (2013) applied the ARDL bounds test approach during 1965- 2010 for Algerian and Egyptian economy. The results suggested cointegration for both countries and bi-causality between energy consumption and growth in the long run. Dagher and Yacoubian (2012) investigated the dynamic causal relationship between energy consumption and economic growth in Lebanon over the period 1980–2009. They found strong evidence of a bidirectional relationship both in the short-run and in the long-run, indicating that energy is a limiting factor to economic growth in Lebanon.

Sarkar and Singh (2010) also showed that energy efficiency programs can conserve natural resources, reduce the environmental pollution and carbon footprint of the energy sector, reduce a country's dependence on fossil fuels, thus enhancing its energy security, ease infrastructure bottlenecks and impacts of temporary power shortfalls, as well as improve industrial and commercial competitiveness through reduced operating costs. Using monthly data for Lebanon, Abosedra, et al. (2009) investigated the causal relationship between electricity consumption and economic growth for Lebanon, Empirical results of the study confirm the absence of a long-term equilibrium relationship between electricity consumption and economic growth but the existence of unidirectional causality running from electricity consumption to economic growth. Belloumi (2009) used Johansen cointegration technique to examine the causal relationship between per capita energy consumption and per capita gross domestic product for Tunisia during 1971–2004. Estimation results indicate that the economic growth and electricity consumption are related by one cointegrating vector and that there is a long-run bi-directional causal relationship between the two series and a short-run unidirectional causality from energy to GDP.

**3. Data and Methodology**

Modelling the relationship between energy consumption and economic growth is carried out on annual data which cover the period 1980–2011. It includes 17 Arab countries: Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen. For some countries, the data is not available for the whole period especially for Libya, Qatar and Iraq were the number of observations is small: 9, 10 and 13, respectively.

This limits the interpretation of empirical results for these countries. The data for both energy consumption and real GDP are taken from the World Bank Group (Ed.). (2012). GDP denotes gross domestic product per unit of energy use while EC denotes energy use in kg of oil equivalent per $1,000 GDP, both measured in constant 2005 PPP.

Before estimating the ARDL model, this study went through three steps. First, we investigated the existence of unit root in the variables. Second, we checked for cointergration and determined the number of cointegrating equations using unrestricted cointegration rank test for both cases: Trace and Maximum Eigenvalue. Third, we applied Granger's causality test to determine the existence and direction of causality between the variables of the model.

**4. The model**

We propose the application of the following Auto Regressive Distributed Lag (ARDL) model:

$$\Delta GDP_{jt} = \alpha_{j0} + \sum_{i=1}^{k} \beta_{ji}\Delta GDP_{j,t-i} + \sum_{i=0}^{l} \gamma_{ji}\Delta EC_{j,t-i} + u_{j1} \quad (1)$$

$$\Delta EC_{jt} = \delta_{j0} + \sum_{i=1}^{m} \varepsilon_{ji}\Delta EC_{j,t-i} + \sum_{i=0}^{n} \zeta_{ji}\Delta GDP_{j,t-i} + u_{j2} \quad (2)$$

Where GDP is the aggregate output and EC is energy consumption. For simplicity, *k, l, m* and *n* represent the maximum number of lags. In this paper, we decided to allow for different lags for each country without fixing the maximum number of lags at a constant value. In this case, it is determined automatically by the estimation method (Least Squares) based on Schwarz Information Criterion (SIC). The index j is the country index (j=1, 2, …, 17), small Greek letters are coefficients to be estimated, and *u*'s are error terms.

The application of ARDL model is based on three validations. First, ARDL model suggests that after specification of the order of the ARDL, one can estimate the level and first difference relationship between variables using ordinary least squares method. Second, the order of integration of appropriate variables may not necessarily be the same. Therefore, the ARDL technique has the advantage of not requiring a specific identification of the order of the underlying data. Third, this technique is suitable for small sample size (Pesaran *et al.*, 2001). The above two equations are actually several equations not only regarding each country but in using a mixture of level variables: *EC* and *GDP* and first difference: $\Delta EC$ and $\Delta GDP$.

**5. Results and Discussion**

We start with testing for the existence of unit root for the variables of the model. After that, we apply cointegration test to see if there are cointegrating equations and make use of the results of this test for model construction. We also apply Granger's causality test to examine the causal relationship between economic growth and energy consumption. Finally, we apply regression analysis to estimate the equations of the proposed model.

*5.1 Unit root test*

An important issue to be considered in estimating any model is to test the stationarity of the variables of the model so that ordinary least squares estimates are not superior. For GDP, the Augmented Dickey Fuller (ADF) test is used in order to test the null hypothesis that the coefficient of lagged GDP is zero which means that there is an unit root. The alternate hypothesis is that it is less than zero, i.e., there is no unit root. More formally we want to test the null hypothesis: $H_0$: $\beta = 0$, versus its alternative $H_1$: $\beta < 0$, based on the following formula:

$$\Delta GDP_t = \alpha + \beta GDP_{t-1} + \sum_{i=1}^{k} \eta_i \, \Delta GDP_{t-i} + u_{t3} \quad (3)$$

For *EC*, the ADF test is employed in order to test the null hypothesis: $H_0$: $\varepsilon = 0$, implying that the variable *EC* has a unit root versus its alternative $H_1$: $\varepsilon < 0$, based on the following equation:

$$\Delta EC_t = \delta + \varepsilon EC_{t-1} + \sum_{i=1}^{m} \theta_i \, \Delta EC_{t-i} + u_{t4} \quad (4)$$

Where $u_t$ is the error term which is assumed to be white noise, *k* and *m* are the maximum numbers of lags, in equations (3) and (4) respectively, and all other small Greek letters are coefficients to be estimated. For simplicity, the country index is omitted but equations (3) and (4) are estimated for each country. The critical values are taken from MacKinnon (1996) who provided response surface regression results for obtaining critical values for four different assumptions about the deterministic regressors in the cointegrating equation: none, constant, linear trend, and quadratic trend. We opted to select the first assumption due to the limitations in the length of the time series.

The assumed null hypothesis is that energy consumption has a unit root while the maximum lag length is automatically selected by the estimation method based on Schwarz Information Criterion (SIC). The assumed null hypothesis is that gross domestic product has a unit root. Unit root test results are presented in Table 1 and 2.

**Table 1. Results of Augmented Dickey-Fuller unit root test for *EC***

| Country name | Lag length | ADF statistic | Critical value 5% | Probability | Conclusion |
|---|---|---|---|---|---|
| Level | | | | | |
| Algeria | 0 (7) | -3.354951 | -2.960411 | 0.0208 | No unit root |
| Egypt, Arab Rep. | 0 (7) | -3.116682 | -2.960411 | 0.0356 | No unit root |
| Iraq | 3 (3) | -3.767790 | -3.175352 | 0.0197 | No unit root |
| Saudi Arabia | 0 (7) | -3.075462 | -2.960411 | 0.0390 | No unit root |
| Syrian Arab Republic | 0 (7) | -3.431371 | -2.967767 | 0.0176 | No unit root |
| First difference | | | | | |
| Bahrain | 2 (7) | -3.827584 | -2.971853 | 0.0072 | No unit root |
| Jordan | 0 (7) | -4.101371 | -2.963972 | 0.0034 | No unit root |
| Lebanon | 0 (5) | -7.619248 | -3.004861 | 0.0000 | No unit root |
| Morocco | 0 (7) | -8.379303 | -2.963972 | 0.0000 | No unit root |
| Oman | 1 (7) | -4.424340 | -2.967767 | 0.0016 | No unit root |
| Sudan | 0 (7) | -5.552861 | -2.963972 | 0.0001 | No unit root |
| Tunisia | 0 (7) | -7.087882 | -2.963972 | 0.0000 | No unit root |
| United Arab Emirates | 0 (7) | -5.172008 | -2.963972 | 0.0002 | No unit root |
| Yemen, Rep. | 0 (4) | -5.103093 | -3.020686 | 0.0006 | No unit root |
| Second difference | | | | | |
| Kuwait | 1 (7) | -9.052135 | -3.004861 | 0.0000 | No unit root |
| Libya | 0 (1) | -3.292347 | -3.320969* | 0.0519* | No unit root* |
| Qatar | 1 (2) | -2.524087 | -3.320969* | 0.1443* | Unit root* |

Notes: The maximum lag length, shown between parentheses, is automatically selected by the estimation method based on SIC. * Probabilities and critical values calculated for 20 observations may not be accurate for small sample size. For Libya and Qatar, the significant level for rejecting unit root is approximately 5% and 14%, respectively.

**Table 2. Results of Augmented Dickey-Fuller unit root test for *GDP***

| Country name | Lag length | ADF statistic | Critical value 5% | Probability | Conclusion |
|---|---|---|---|---|---|
| Level | | | | | |
| Algeria | 0 (7) | -4.431629 | -2.960411 | 0.0014 | No unit root |
| Egypt, Arab Rep. | 0 (7) | -3.515530 | -2.960411 | 0.0142 | No unit root |
| Iraq | 3 (3) | -3.670224 | -3.175352 | 0.0229 | No unit root |
| Lebanon | 0 (5) | -3.861550 | -2.998064 | 0.0078 | No unit root |
| Saudi Arabia | 0 (7) | -7.701848 | -2.960411 | 0.0000 | No unit root |
| Syrian Arab Republic | 1 (7) | -4.760747 | -2.967767 | 0.0007 | No unit root |
| United Arab Emirates | 0 (7) | -6.814436 | -2.960411 | 0.0000 | No unit root |
| First difference | | | | | |
| Bahrain | 2 (7) | -3.948780 | -2.971853 | 0.0054 | No unit root |
| Jordan | 0 (7) | -5.061444 | -2.963972 | 0.0003 | No unit root |
| Kuwait | 0 (7) | -4.525074 | -2.981038 | 0.0014 | No unit root |
| Morocco | 0 (7) | -8.255102 | -2.963972 | 0.0000 | No unit root |
| Oman | 3 (7) | -2.919525 | -2.976263 | 0.0562 | No unit root |
| Sudan | 0 (7) | -6.278570 | -2.963972 | 0.0000 | No unit root |
| Tunisia | 0 (7) | -8.302602 | -2.963972 | 0.0000 | No unit root |

| | | | | | |
|---|---|---|---|---|---|
| Yemen, Rep. | 0 (4) | -5.057937 | -3.020686 | 0.0007 | No unit root |
| Second difference | | | | | |
| Libya | 0 (1) | -3.292347 | 3.320969* | 0.0519* | No unit root |
| Qatar | 1 (2) | -2.524087 | -3.320969* | 0.1443* | Unit root |

Notes: The maximum lag length, shown between parentheses, is automatically selected by the estimation method based on SIC. * Probabilities and critical values calculated for 20 observations may not be accurate for small sample size. For Libya and Qatar, the significant level for rejecting unit root is approximately 5% and 14%, respectively.

*5.2 Cointegration test*

The study of cointegrating relationships has been a particularly active area of research. Since the unit root tests confirm that both variables are I(1) for some countries, then the next step would be to test if they are cointegrated or, in other words, if they are bound by a long-run relationship. This study applies Johansen's cointegration approach to test for cointegration and to determine the number of cointegrating equations. After that, the non-stationary variables, at level, are differenced and a simple unrestricted VAR is employed. The results of cointegration test are shown in Table 3 and Table 4.

**Table 3. Unrestricted Cointegration Rank Test (Trace)**

| Country | Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|---|
| Algeria 1982-2011 | None * | 0.853931 | 61.54473 | 15.49471 | 0.0000 |
| | At most 1 | 0.119982 | 3.834397 | 3.841466 | 0.0502 |
| Bahrain 1982-2011 | None | 0.294550 | 10.86676 | 15.49471 | 0.2198 |
| | At most 1 | 0.013218 | 0.399198 | 3.841466 | 0.5275 |
| Egypt 1982-2011 | None * | 0.334943 | 19.06337 | 15.49471 | 0.0139 |
| | At most 1 * | 0.203528 | 6.826909 | 3.841466 | 0.0090 |
| Iraq 1999-2011 | None * | 0.621290 | 17.42647 | 15.49471 | 0.0253 |
| | At most 1 * | 0.308928 | 4.803652 | 3.841466 | 0.0284 |
| Jordan 1982-2011 | None | 0.302859 | 11.28535 | 15.49471 | 0.1945 |
| | At most 1 | 0.015293 | 0.462321 | 3.841466 | 0.4965 |
| | | | | | |
| Kuwait 1982-2011 | None * | 0.353464 | 21.86843 | 15.49471 | 0.0048 |
| | At most 1 * | 0.333002 | 10.52916 | 3.841466 | 0.0012 |
| Lebanon 1990-2011 | None | 0.374421 | 11.38024 | 15.49471 | 0.1892 |
| | At most 1 | 0.047063 | 1.060532 | 3.841466 | 0.3031 |
| Libya 2001-2009 | None * | 0.779652 | 18.46207 | 15.49471 | 0.0173 |
| | At most 1 * | 0.416548 | 4.849139 | 3.841466 | 0.0276 |
| Morocco 1982-2011 | None | 0.320765 | 13.16601 | 15.49471 | 0.1089 |
| | At most 1 | 0.050746 | 1.562368 | 3.841466 | 0.2113 |
| Oman 1982-2011 | None | 0.223825 | 7.873097 | 15.49471 | 0.4791 |
| | At most 1 | 0.009019 | 0.271788 | 3.841466 | 0.6021 |
| | | | | | |
| Qatar 2002-2011 | None | 0.708781 | 12.93691 | 15.49471 | 0.1172 |
| | At most 1 | 0.058245 | 0.600096 | 3.841466 | 0.4385 |
| Saudi Arabia 1982-2011 | None * | 0.570054 | 28.63390 | 15.49471 | 0.0003 |
| | At most 1 | 0.104494 | 3.311004 | 3.841466 | 0.0688 |
| Sudan 1982-2011 | None | 0.198343 | 6.638067 | 15.49471 | 0.6201 |
| | At most 1 | 0.000194 | 0.005833 | 3.841466 | 0.9384 |
| Syria 1982-2010 | None * | 0.882138 | 70.67029 | 15.49471 | 0.0000 |
| | At most 1 * | 0.258194 | 8.661340 | 3.841466 | 0.0033 |
| Tunisia 1982-2011 | None | 0.338690 | 12.43966 | 15.49471 | 0.1370 |
| | At most 1 | 0.001122 | 0.033681 | 3.841466 | 0.8543 |
| United Arab Emirates 1982-2011 | None * | 0.636721 | 38.09345 | 15.49471 | 0.0000 |
| | At most 1 * | 0.226785 | 7.715959 | 3.841466 | 0.0055 |
| Yemen 1992-2011 | None | 0.443488 | 12.55313 | 15.49471 | 0.1323 |
| | At most 1 | 0.040736 | 0.831782 | 3.841466 | 0.3618 |

Notes: * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values.

Based on Trace method, presented in Table 3, the null hypotheses of no cointegration is rejected in the case of Algeria, Egypt, Iraq, Kuwait, Libya, Saudi Arabia, Syria, and United Arab Emirates. The results of unrestricted cointegration rank test using Maximum Eigenvalue method, shown in Table 4 are almost similar to those of Trace method. The null hypothesis of no cointegration is rejected in the case of Algeria, Saudi Arabia, Syria, and United Arab Emirates at 5% level of significant and in the case of Egypt, Iraq, Libya, Qatar and Tunisia at 10% level of significant.

**Table 4. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**

| Country | Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|---|
| Algeria 1982-2011 | None * | 0.853931 | 57.71033 | 14.26460 | 0.0000 |
| | At most 1 | 0.119982 | 3.834397 | 3.841466 | 0.0502 |
| Bahrain 1982-2011 | None | 0.294550 | 10.46756 | 14.26460 | 0.1830 |
| | At most 1 | 0.013218 | 0.399198 | 3.841466 | 0.5275 |
| Egypt 1982-2011 | None | 0.334943 | 12.23647 | 14.26460 | 0.1021 |
| | At most 1 * | 0.203528 | 6.826909 | 3.841466 | 0.0090 |
| Iraq 1999-2011 | None | 0.621290 | 12.62282 | 14.26460 | 0.0894 |
| | At most 1 * | 0.308928 | 4.803652 | 3.841466 | 0.0284 |
| Jordan 1982-2011 | None | 0.302859 | 10.82302 | 14.26460 | 0.1633 |
| | At most 1 | 0.015293 | 0.462321 | 3.841466 | 0.4965 |
| | | | | | |
| Kuwait 1982-2011 | None | 0.353464 | 11.33927 | 14.26460 | 0.1380 |
| | At most 1 * | 0.333002 | 10.52916 | 3.841466 | 0.0012 |
| Lebanon 1990-2011 | None | 0.374421 | 10.31971 | 14.26460 | 0.1918 |
| | At most 1 | 0.047063 | 1.060532 | 3.841466 | 0.3031 |
| Libya 2001-2009 | None | 0.779652 | 13.61293 | 14.26460 | 0.0632 |
| | At most 1 * | 0.416548 | 4.849139 | 3.841466 | 0.0276 |
| Morocco 1982-2011 | None | 0.320765 | 11.60364 | 14.26460 | 0.1264 |
| | At most 1 | 0.050746 | 1.562368 | 3.841466 | 0.2113 |
| Oman 1982-2011 | None | 0.223825 | 7.601308 | 14.26460 | 0.4207 |
| | At most 1 | 0.009019 | 0.271788 | 3.841466 | 0.6021 |
| | | | | | |
| Qatar 2002-2011 | None | 0.708781 | 12.33681 | 14.26460 | 0.0986 |
| | At most 1 | 0.058245 | 0.600096 | 3.841466 | 0.4385 |
| Saudi Arabia 1982-2011 | None * | 0.570054 | 25.32289 | 14.26460 | 0.0006 |
| | At most 1 | 0.104494 | 3.311004 | 3.841466 | 0.0688 |
| Sudan 1982-2011 | None | 0.198343 | 6.632234 | 14.26460 | 0.5335 |
| | At most 1 | 0.000194 | 0.005833 | 3.841466 | 0.9384 |
| Syria 1982-2010 | None * | 0.882138 | 62.00895 | 14.26460 | 0.0000 |
| | At most 1 * | 0.258194 | 8.661340 | 3.841466 | 0.0033 |
| Tunisia 1982-2011 | None | 0.338690 | 12.40598 | 14.26460 | 0.0963 |
| | At most 1 | 0.001122 | 0.033681 | 3.841466 | 0.8543 |
| | | | | | |
| United Arab Emirates 1982-2011 | None * | 0.636721 | 30.37749 | 14.26460 | 0.0001 |
| | At most 1 * | 0.226785 | 7.715959 | 3.841466 | 0.0055 |
| Yemen 1992-2011 | None | 0.443488 | 11.72135 | 14.26460 | 0.1215 |
| | At most 1 | 0.040736 | 0.831782 | 3.841466 | 0.3618 |

Notes: * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values.

*5.3 Granger causality test*

The test for the direction of causality is based on the assumption that the number of lags ranges from 1 to 7, using Schwarz Information Criterion (SIC) to determine the optimal solution. Table 5 presents the results of testing Granger's causality that runs from real GDP to energy consumption for all Arab countries. The results do not reject the null hypotheses of no causality in the case of each Arab country with the exception of Kuwait. In Table 6, there is clear evidence that no causality runs from energy consumption to real GDP except in the case of Kuwait. Looking at the results in Tables 5 and 6, together, there is a clear evidence of neutrality hypothesis. The results support the neutrality hypothesis for almost all Arab countries, which implies that energy consumption and economic growth are not sensitive to one another. Therefore, any policy with respect to the consumption of energy, conservative or expansive, is expected to have a negligible effect on economic growth. The feedback hypothesis is confirmed only in the case of Kuwait which implies that energy conservation policy will adversely affect the economic output and an increase in the economic output will increase the level of energy consumption.

It should be noted that less evidence should be attached to the empirical results for Libya, Qatar and Iraq, since the number of observations is small: 9, 10 and 13, respectively.

**Table 5. Results of Granger causality test for no causality from GDP to EC**

| Country | $H_0$: GDP does not Granger cause energy consumption (EC)<br>$H_1$: GDP $\rightarrow$ EC | | | |
|---|---|---|---|---|
| | Observations | F-Statistic | Probability | Decision |
| Algeria | 30 | 0.92946 | 0.4080 | No causality |
| Bahrain | 30 | 3.13614 | 0.0609* | No causality |
| Egypt, Arab Rep. | 30 | 0.75773 | 0.4792 | No causality |
| Iraq | 13 | 1.68357 | 0.2453 | No causality |
| Jordan | 30 | 0.55339 | 0.5819 | No causality |
| | | | | |
| Kuwait | 26 | 8.09127 | 0.0025*** | GDP $\rightarrow$ EC |
| Lebanon | 22 | 0.72870 | 0.4970 | No causality |
| Libya | 9 | 0.97513 | 0.4519 | No causality |
| Morocco | 30 | 0.21318 | 0.8095 | No causality |
| Oman | 30 | 0.92285 | 0.4105 | No causality |
| | | | | |
| Qatar | 10 | 0.30136 | 0.7524 | No causality |
| Saudi Arabia | 30 | 0.22992 | 0.7963 | No causality |
| Sudan | 30 | 0.00219 | 0.9978 | No causality |
| Syrian Arab Republic | 29 | 0.69586 | 0.5084 | No causality |
| Tunisia | 30 | 0.17652 | 0.8392 | No causality |
| | | | | |
| United Arab Emirates | 30 | 2.22945 | 0.1285 | No causality |
| Yemen, Rep. | 20 | 0.02492 | 0.9754 | No causality |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table 6. Results of Granger causality test for no causality from EC to GDP**

| Country | $H_0$: Energy consumption (EC) does not Granger cause GDP<br>$H_1$: EC $\rightarrow$ GDP | | | |
|---|---|---|---|---|
| | Observations | F-Statistic | Probability | Decision |
| Algeria | 30 | 2.38248 | 0.1130 | No causality |
| Bahrain | 30 | 2.20246 | 0.1315 | No causality |
| Egypt, Arab Rep. | 30 | 0.96638 | 0.3942 | No causality |
| Iraq | 13 | 3.07317 | 0.1023 | No causality |
| Jordan | 30 | 0.36669 | 0.6967 | No causality |
| | | | | |
| Kuwait | 26 | 7.36934 | 0.0038*** | EC $\rightarrow$ GDP |
| Lebanon | 22 | 1.31457 | 0.2945 | No causality |
| Libya | 9 | 1.10054 | 0.4161 | No causality |
| Morocco | 30 | 0.07686 | 0.9262 | No causality |
| Oman | 30 | 1.26105 | 0.3008 | No causality |
| | | | | |
| Qatar | 10 | 0.48349 | 0.6427 | No causality |
| Saudi Arabia | 30 | 1.63689 | 0.2148 | No causality |
| Sudan | 30 | 0.47549 | 0.6271 | No causality |
| Syrian Arab Republic | 29 | 0.45191 | 0.6417 | No causality |
| Tunisia | 30 | 0.18420 | 0.8329 | No causality |

| | | | | |
|---|---|---|---|---|
| United Arab Emirates | 30 | 2.76914 | 0.0820* | No causality |
| Yemen, Rep. | 20 | 0.07186 | 0.9310 | No causality |

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

## 6. Conclusions

We investigated the relation between energy consumption and economic growth in 17 Arab countries over the period 1980-2011, using ARDL model. The results indicate that no causality runs from energy consumption to real GDP and no causality runs from real GDP to energy consumption in all Arab countries except in the case of Kuwait. Empirical results confirm the neutrality hypotheses were linkage between energy consumption and economic growth is insignificant, for 16 out of 17 Arab countries. This means that policies aiming at energy conservation in Arab countries do not limit economic growth and, hence, shocks to energy supply will have insignificant impact on economic growth. It also implies that changes in economic growth are unlikely to have significant effect on energy consumption. The feedback hypothesis is confirmed only in the case of Kuwait. The findings for Iraq, Kuwait and Libya should be cautiously interpreted since these countries went through political instability which affected the accuracy of data.

It should be noted that there are some differences between the findings of this paper and the findings of those studies that considered some Arab countries using different methodologies. Therefore, we recommend further analysis to focus more on the new approaches that use the same methodology across Arab countries when judging about the relationship between economic growth and energy use.

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