Energy Consumption and Economic Growth in Jordan: An ARDL Bounds Testing Approach to Cointegration

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ABSTRACT

This paper has two purposes: to examine the role of energy consumption in stimulating economic growth in Jordan and to investigate the direction of causality between energy consumption and economic growth in Jordan using annual data over the period 1980-2012. To accomplish the first purpose an Autoregressive Distributed Lag (ARDL) approach is used to estimate a logarithmic version of traditional neo-classical aggregated production function where output is a function of energy, capital and labor. Based on the estimates, long-run elasticities of output with respect to energy, capital and labor are found to be 0.85, 0.30 and 0.37, respectively. While, the short-run estimates are 0.29, 0.24 and 0.28, respectively. Granger-Causality test demonstrates a positive bi-directional relationship between energy consumption and economic growth supporting a feedback hypothesis; under this hypothesis energy consumption and real GDP are determined together suggesting that a policy of energy conservation would tend to slow economic growth in Jordan.

1. INTRODUCTION

Whether energy is a direct or an intermediate factor of production is subject to debate. In brief, Ghali and El-Sakka (2004) summarize the debate around this issue by two points of view; the neo-classical view which assumes that energy is neutral to economic growth or what has been known as the "*neutrality hypothesis*". The other view, which is adopted by ecological economists, assumes that energy is the primary factor of production. According to this view, energy is a "*limiting factor"* to economic growth.[1]

However, regardless of that debate, the vital role of energy in stimulating economic growth cannot be neglected. This has been widely subject to empirical investigation and more specifically, testing the direction of causality between energy consumption and economic growth was of particular interest. As will be discussed shortly, determining the direction of causality has an important policy implication in terms of whether to promote or discourage energy conserving measures. In the literature of energy economics, four hypotheses have been widely subject to testing. Sometimes these hypotheses are named neutrality, conservation, growth and feedback hypotheses.[2] As shown soon, each one of these hypothesis has different implications for designing proper energy policy.

Based on the above introduction, doing this research can be justified on three grounds: examining the role of energy consumption in stimulating economic growth in Jordan, testing the direction of causality between energy consumption and economic growth and investigating which one of the four above-mentioned hypotheses is

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applicable for Jordan. This is of interest in itself, especially that the findings of empirical research are not consistent about the direction of this relationship and they are even sometimes contradictory for the same country. As noted by Tsani (2010), among others, this is extremely important because energy conserving policies could be in conflict with a policy of promoting economic growth goal if empirical evidence indicates that the country is likely to be energy-dependent. Therefore, the empirical results of this study might provide policymakers in Jordan with some insights towards formulating proper energy policies. Finally, it is hoped that this study will contribute to closing some of the gap in the literature of energy economics for Jordan and to constitute a baseline for future studies within this scope, especially that to the best of our knowledge, the literature lacks such a study devoted for Jordan *per se*. Nonetheless, there are few studies that analyzed Jordan within the context of a group of other countries, but still this study distinguishes itself from others in a number of ways. It analyzes Jordan as a single country.[3] Uses multivariate framework of analysis, which in contrast to bivariate framework, captures indirect channels of causality. Finally, it uses the ARDL methodology of cointegration, as recommended by Ozturk (2010), which has a number of advantages over other methods of cointegration, as discussed later.

The remainder of the paper is organized as follows. Section 2 contains a review of the literature and related work. Section 3 describes the model and empirical methodology. Data and variables are described in section 4. Section 5 discusses empirical findings and finally section 6 concludes the paper and provides some policy implications.

2. Literature Review and Related Work

Ozturk (2010) and Squalli (2007), among others, summarize the following four hypotheses, which are investigated in this strand of energy economics literature, along with their implications to designing proper energy policies.

a) Neutrality hypothesis: assumes the absence of causality between energy and growth. Therefore, neither conservative nor expansive energy consumption policies have any effect on economic growth.

b) Conservation hypothesis: presumes the existence of uni-directional causality running from economic growth to energy consumption, i.e., the economy is less dependent on energy. Consequently, implementing an energy conserving policy does not have an adverse impact on economic growth.

c) Growth hypothesis: posits that uni-directional causality runs from energy consumption to economic growth. In other words, it can be theoretically inferred that the economy is energy-dependent. Accordingly, implementing an energy conserving policy will slow economic growth.

d) Feedback hypothesis: posits that a bi-directional causality between energy consumption and economic growth exists, which implies that energy consumption and economic growth complement each other or are determined together.

However, as highlighted by Squalli (2007), the policy implications coming out of these hypotheses are valid under the assumption of positive causality, but when causality is negative, the conclusion about energy-dependence is less clear and interpretation should be provided with caution. It is worthwhile noting that most authors overlook this issue. Narayan et al. (2010, p. 1054) maintain that "*The bulk of the extant literature has assumed a positive relationship between energy consumption and real GDP*".[4]

Since the seminal work of Kraft and Kraft (1978), a great number of empirical studies were undertaken to identify the casual relationship between economic growth and energy consumption.[5] In terms of the country under investigation, those studies might be

classified into country-specific studies, including Baranzini et al. (2013), Shaari et al. (2012), Landolsi and Ben Rejeb (2011), Magazzino (2011), Tsani (2010) and Cheng and Lai (1997) and Kraft and Kraft (1978), among many others. While the rest are multi-country studies, including Yazdani and Faaltofighi (2013), Hossein et al. (2012), Narayan and Popp (2012), Narayan et al. (2010), Soytas and Sari (2003) and Asafu-Adjaye (2000), to mention a few.

However, as noted by Masih and Masih (1997), the causality studies of energy consumption and economic growth are highly controversial across time and across country. According to them, among the factors that produce conflicting findings are methodological differences, definitional specifications of the variables, as well as the type of causality techniques, tests, and lag structures employed in these studies. In his literature survey on energy-growth nexus, Ozturk (2010) agrees with the conclusion of Masih and Masih (1997) and adds that the empirical findings are mixed and sometimes contradictory for the same country. He attributes this to differences in data sets, econometric methods and to the variables used in these empirical models, in addition to differences in countries' characteristics. To avoid conflicting results, Ozturk proposes two substantial recommendations. On the model building and variable selection front, he recommends researchers to consider other variables in addition to those that are usually considered in such studies, namely; energy consumption and GDP. More specifically, he proposes the inclusion of new variables such as real gross fixed capital formation and labor force, among others.[6] On the methodological front he recommends the use of the autoregressive distributed lags bounds test (ARDL) pioneered by Pesaran et al. (2001), among other techniques.[7]

Next, some of the recent empirical work that has shown up after Ozturk (2010) and Payne (2010a, b) is discussed.[8] At the level of single countries, Baranzini et

al. (2013) investigate the relationship between energy use and economic growth for Switzerland over the period 1950-2010 using ARDL. They find that conserving energy policies do not necessarily have negative impact on Swiss economic growth. Shaari et al. (2012) examine the relationship between energy consumption and economic growth in Malaysia over the period 1980 to 2010 using cointegration and Granger causality. Their main conclusion is that conserving policies of utilizing gas would have undesirable impacts on economic growth in Malaysia. Landolsi et al. (2011) investigate the energy-growth nexus for Tunisia over the period 1971-2009. They find that causality runs from economic growth to energy consumption therefore energy saving policies would not have undesirable impacts on economic growth. Magazzino (2011), tests the nexus between aggregate income and energy consumption for Italy over the period 1970-2009. He concludes that energy is a limiting factor to GDP growth in Italy. Tsani (2010) investigates the causal relationship between energy consumption and economic growth for Greece for the period 1960–2006 at aggregated and at disaggregated levels. She finds that the energy conservation policies would not have negative impacts on GDP.

Among multi-country studies, Yazdani and Faaltofighi (2013) investigate the causality between energy consumption and economic growth in a selected number of oil exporting countries and oil importers over the period 1980-2007.[9] They conclude that in oil exporting countries increase in energy consumption boosts economic growth and vice versa. However in oil importing countries, energy conserving policies need not have deteriorate impact on economic growth.

Hossein et al. (2012) test the Granger causality between energy consumption and economic growth for Organization of Petroleum Exporting Countries (OPEC) countries for the period 1980-2008.[10] They conclude that reducing energy consumption will not negatively affect

economic growth rather it will reduce CO2 emissions. Narayan et al. (2010) while avoiding traditional examination of Granger causality as done in most of the underlying energy studies, they examine the implicit assumption, assumed in many studies, of a *positive* relationship between energy consumption and economic growth. To that end, they estimate long run elasticities between energy consumption and real GDP for 93 countries. Also they study the long run relationship for a group of panels over the period 1980-2006.[11] They find that in about 59% of the countries, energy consumption has positive impact on real GDP in the long run. They also find that in nearly 61% of the countries, real GDP has positive impact on energy consumption in the long run. Narayan and Popp (2012) investigate the long-run impact of energy consumption on real GDP for 93 countries and for a variety of panels (see footnote 11 for a description of the panels) over the period 1980-2006 using panel fully modified ordinary least squares. They find that at the individual country level, the impact of energy on GDP is not the same for all the countries. However, at the level of panels, the impact is minimal for all the panels, therefore energy conservation policies will benefit some but not all the countries. For the G6 panel, they conclude that energy saving policies will not hinder economic growth in these countries; therefore these countries should utilize these policies to reduce carbon dioxide.

As highlighted above, none of the previous studies have analyzed growth-energy causality in Jordan as a single country; therefore no baseline, to which the results of the current study can be compared with, is available. However, some research papers analyze Jordan among a group of countries. For example, Omri (2013) utilizes simultaneous-equations models to examine the nexus between CO2 emissions, energy consumption and economic growth using panel data of 14 countries over the period 1990–2011. He finds that energy consumption has an insignificant positive impact on real GDP per capita in Jordan while real GDP per capita has a significant positive impact on energy consumption per capita. He also finds that capital positively affect real GDP per capita. Ozturk and Acaravci (2011) use ARDL to investigate the long run and short run causality between electricity consumption and economic growth for 11 Arab countries including Jordan over the period 1971-2006. Surprisingly, Jordan among other countries does not satisfy the ARDL assumptions therefore it was dropped out of the analysis.[12] Bouoiyour and Selmi (2012) investigate the causality between electricity consumption and economic growth of twelve Arab countries over the period 1975–2010 within a panel framework. Out of these countries, seven are energy exporters and five are energy importers including Jordan.[13] For Jordan, a uni-directional relationship flowing from GDP to electricity consumption is found, which in turn provides evidence supporting the conservation hypothesis.

Shahateet (2014) investigates the relationship between energy consumption and real economic growth in 17 Arab countries including Jordan over the period 1980-2011 using ARDL approach.[14] He finds no Granger causality neither from energy to GDP nor from GDP to energy in Jordan. Lee and Chang (2008) analyze within an aggregate production function framework (in which labor and capital in addition to energy are the factors of production) the causality between energy consumption and real GDP for a panel of 16 Asian countries including Jordan over period the 1971–2002. As discussed later in detail, some the findings of this study are compatible with the findings of our results (for example the elasticities of output with respect to energy and labor), however, some results are in sharp contrast (for example the elasticity of output with respect to capital).

Chontanawat et al. (2006) test the direction of causality for 30 OECD (Organization for Economic Co-operation and Development) and 78 non-OECD

countries including Jordan over the period 1971-2000.[15] Their main conclusion for Jordan was the existence of a bi-directional causality between energy and GDP. Chontanawat et al. (2008) test causality between energy and GDP for over 100 countries including Jordan as one of the non-OECD countries. Empirical evidence shows that Granger causality is running from energy to GDP in Jordan. Therefore, conserving policies of energy consumption could deteriorate economic growth in Jordan.

Farhani and Ben Rajeb (2012) analyze the relationship between GDP and energy consumption using panel data for a set of 95 countries including Jordan for the period 1971-2008.[16] Evidence supports the existence of a bi-directional causality between energy and GDP in Jordan. Narayan et al. (2010) find that real GDP has negative effect on energy consumption in Jordan. Also in the long run, energy consumption has negative impact on real GDP. Narayan and Popp (2012) find that real GDP negatively Granger causes energy consumption in Jordan, implying that an increase in GDP will cut energy consumption. As one would expect, the results are mixed and not consistent for the reasons discussed above (please See Table A1 in the appendix for a summary of some of those studies).

3. Model and Empirical Methodology

3.1 Model Specification

As earlier discussed, a great volume of papers examining the causality between energy and economic growth use a bivariate framework, where the only variables under investigation are energy consumption and GDP. Yuan et al. (2008, p. 3078) state that "Though bivariate model [sic] has merit that they can be employed with scarce data, recently its limitation to describe energy–economy interactions has been criticized". This statement reflects, implicitly, the possibility of bias caused by the omission of relevant variables. Within the same context, Lütkepohl (1982) demonstrates that it is difficult or impossible to draw conclusions about the relationship between a few economic variables if other relevant variables are not included into the model. On the other hand, Stern (1993) discusses the advantages of multivariate framework over bivariate one. In particular he argues that the inclusion of capital stock and labor as a part of a VAR model might be useful in estimating the true correlation between energy and output. An additional benefit of multivariate framework is that it allows the investigation of *indirect* channels of causation from energy use to GDP (Stern, 1993 and Lee and Chang, 2008). Moreover, as Stern (2000) points out the multivariate framework captures substitution effects between energy and the other factors of production such as capital and labor.

Following Lee and Chang (2008), Yuan et al. (2008), Ghali and El-Sakka (2004) and Stern (1993, 2000), a traditional neo-classical aggregate production function is employed for the purpose of exploring the relationship between energy consumption and economic growth. According to this model, aggregate output (which is proxied by the GDP) is expressed as a function of three factors of production: energy, capital stock and labor:

$$GDP = f(energy, capital, labor) \qquad (1)$$

In order to operationalize Eq. (1), the logarithmic form of the Cobb-Douglas[17] production function was applied to capture the long-run relationship between aggregate output and the factors of production:

$$\ln(Y_t) = A + \beta_1 \ln E_t + \beta_2 \ln K_t + \beta_3 \ln L_t + u_t \qquad (2)$$

Where $\ln$ denotes natural logarithm. The coefficients: A, β_1, β_2 and β_3 are parameters to be estimated. A is interpreted as the intercept, $\beta_i, i = 1,2,3$ are interpreted as the elasticities of output with respect to energy, capital and labor, respectively. Y_t is real GDP, E_t is energy consumption, K_t denotes capital stock, L_t stands for labor and u_t is a stochastic error term

assumed to be normally distributed. The subscript t represents time ($t = 1980 - 2012$).

Before estimating Eq. (2), the null hypothesis of non-stationarity for all variables in the model should be tested using the Augmented Dickey Fuller (ADF) test. If none of the variables is I(2), the next step is testing for cointegration using the ARDL bounds test as defined by Pesaran et al. (2001).[18] The key advantage of the ARDL technique over other techniques of testing cointegration including Engle & Granger method and Johansen is that ARDL can be used irrespective whether the variables are stationary I(0) or integrated of order one I(1) or a mix of both, whereas other methods are applicable in cases where the variables are integrated of order one, also, ARDL is appropriate for small samples.[19]

The ARDL model is represented by the unrestricted error correction model (UECM) described in Eq. (3).

$$\Delta \ln Y_t = \alpha_0 + \alpha_Y \ln Y_{t-1} + \alpha_E \ln E_{t-1} + \alpha_K \ln K_{t-1} + \alpha_L \ln L_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \ln Y_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln E_{t-j} + \sum_{m=0}^{r} \alpha_m \Delta \ln K_{t-m} + \sum_{n=0}^{s} \alpha_n \Delta \ln L_{t-n} + \varepsilon_t \qquad (3)$$

Where Δ denotes the first difference operator and α_0 represents the intercept. The coefficients $\alpha_Y, \alpha_E, \alpha_K$ and α_L are the long-run coefficients. While $\alpha_i, \alpha_j, \alpha_m$ and α_n are the short-run coefficients. ε_t denotes a white noise error term, whereas p, q, r and s represent the lag lengths. The ARDL bounds testing approach to cointegration depends on the critical values calculated by Pesaran et al. (2001). After determining the appropriate lag structure,[20] the F-test is applied to determine the presence of a long-run relationship by restricting the coefficients of the lagged level variables to zero, i.e., by excluding Y_{t-1}, E_{t-1}, K_{t-1} and L_{t-1} from Eq. (3). In other words, the following null hypothesis of no cointegration:

$H_0: \alpha_Y = \alpha_E = \alpha_K = \alpha_L = 0$ is tested against the alternative hypothesis $H_a: \alpha_Y \neq \alpha_E \neq \alpha_K \neq \alpha_L \neq 0$.

The next step is to compare the calculated F-statistic with the lower critical bound (LCB) and the upper critical bound (UCB) values reported in Pesaran et al. (2001). If the calculated F-value is greater than the UCB then the null of no cointegration is rejected. If the calculated F- statistic is smaller than the LCB then the null of no cointegration is not rejected. If the calculated F- statistic lies between the LCB and UCB then statistical evidence with respect to the existence of a valid long-run relationship between the variables is inconclusive (i.e., no conclusion can be drawn). For simplicity let Eq. (3) be denoted by:

$$F_Y(Y_t/E_t, K_t, L_t) \qquad (4)$$

Then the above steps are repeated for other three equations in which the dependent variable in Eq. (3) is changed to $\Delta \ln E_t$, $\Delta \ln K_t$ and $\Delta \ln L_t$, respectively. For convenience, denote these equations as follows:

$$F_E(E_t/Y_t, K_t, L_t) \qquad (5)$$

$$F_K(K_t/E_t, Y_t, L_t) \qquad (6)$$

$$F_L(L_t/E_t, K_t, Y_t) \qquad (7)$$

If the statistical evidence supports the alternative hypothesis of a valid long-run relationship between the variables, then a long-run relationship can be estimated using the following conditional ARDL model.[21]

$$\ln Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \ln Y_{t-i} + \sum_{j=0}^{q} \alpha_j \ln E_{t-j} + \sum_{m=0}^{r} \alpha_m \ln K_{t-m} + \sum_{n=0}^{s} \alpha_n \ln L_{t-n} + \varepsilon_t \qquad (8)$$

3.2 Granger Causality using Vector Error Correction Model (VECM)

If the underlying variables are cointegrated, a vector error correction model (VECM) can be used to carry out the causality test both in the short run and the long run. The VECM will take the following form for GDP,

energy consumption, capital and labor, respectively.

$$\Delta \ln Y_t = \rho_0 + \sum_{i=1}^{p} \gamma_i \Delta \ln Y_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta \ln E_{t-j} +$$
$$\sum_{m=0}^{r} \gamma_m \Delta \ln K_{t-m} + \sum_{n=0}^{s} \gamma_n \Delta \ln L_{t-n} +$$
$$\gamma_{11} ECT_{t-1} + u_{1t} \qquad (9)$$

$$\Delta \ln E_t = \rho_1 + \sum_{i=0}^{p} \gamma_i \Delta \ln Y_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta \ln E_{t-j} +$$
$$\sum_{m=0}^{r} \gamma_m \Delta \ln K_{t-m} + \sum_{n=0}^{s} \gamma_n \Delta \ln L_{t-n} +$$
$$\gamma_{22} ECT_{t-1} + u_{2t} \qquad (10)$$

$$\Delta \ln K_t = \rho_2 + \sum_{i=0}^{p} \gamma_i \Delta \ln Y_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta \ln E_{t-j} +$$
$$\sum_{m=0}^{r} \gamma_m \Delta \ln K_{t-m} + \sum_{n=0}^{s} \gamma_n \Delta \ln L_{t-n} +$$
$$\gamma_{33} ECT_{t-1} + u_{3t} \qquad (11)$$

$$\Delta \ln L_t = \rho_3 + \sum_{i=0}^{p} \gamma_i \Delta \ln Y_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta \ln E_{t-j} +$$
$$\sum_{m=0}^{r} \gamma_m \Delta \ln K_{t-m} + \sum_{n=1}^{s} \gamma_n \Delta \ln L_{t-n} +$$
$$\gamma_{44} ECT_{t-1} + u_{4t} \qquad (12)$$

Where $\rho_i, i = 0,1,2,3$ are the intercepts. $\gamma_{11}, \gamma_{22}, \gamma_{33}, \gamma_{44}$ represent the speed of adjustment parameter. ECT_{t-1} represents a one period lagged error correction term derived form the cointegration equation.[22] The determination of the direction of causality in the short run depends on the significance of $\gamma_i, \gamma_j, \gamma_m, \gamma_n$, while in the long run, the direction of causality is determined by the significance of $\gamma_{11}, \gamma_{22}, \gamma_{33}, \gamma_{44}$.

4. Description of the Variables and the Data Sets

Annual time series data over the period (1980-2012) are used. Data on GDP at constant market prices (1994=100) is taken form the online database of the Central Bank of Jordan (CBJ) measured in million Jordanian Dinars (JD million). While data about primary energy consumption measured in thousand tons of oil equivalent (000 toe) is collected from the annual reports of the Ministry of Energy and Mineral Resources (MEMR) and from the annual reports of the Jordan Electricity Authority (JEA).[23] To generate a series for capital stock, the incremental capital-output ratio (ICOR) method described by Eq. (13) is used (see Hammad, 1986).

$$ICOR(1980 - 2012) = \frac{\sum_{t=1980}^{2012} I_t}{(GDP_{2012} - GDP_{1980})} \qquad (13)$$

Where I_t: is net capital formation in the year t. And GDP_{1980} and GDP_{2012} represent gross domestic product for the years 1980 and 2012, respectively.

Using Eq. (13), the value of the ICOR is found to be (4.425). As a first step, this ratio is multiplied by gross domestic product figure for 1980, to get the figure of the capital stock for the first year. Then by cumulating net capital formulation we get figures for the capital stock for the years 1980-2012. To get real figures, this series is adjusted by the Consumer Price Index (CPI) series for the period 1980-2012. Finally, the labor variable is proxied by the compensation of employees. This series is also adjusted using CPI series for the period 1980-2012.

According to these figures, consumption of primary energy has increased dramatically from 1.830 million toe in 1980 to 7.979 million toe in 2012, which is approximately equivalent to an annual growth rate of 10.5%. GDP at constant prices has risen from JD 2818.1 million in 1980 to JD 10515.3 million in 2012, this comprises an annual growth rate of 8.5%. Estimates of cumulative capital stock were JD 12468.85 million in 1980 then they reached JD 43835.713 million in 2012 (equivalent to an annual growth rate of 7.7%). Finally, employees' compensation went up from JD 435.7 million in 1980 to 7084.47 in 2012 (this comprises an approximate annual growth rate of 47.7% percent).[24]

5. Empirical Findings

5.1 Stationarity Test

To test the stationarity of the underlying variables, the standard augmented unit root test of Dickey and Fuller is used. The results (see Table 1) show that none of the series is stationary at the level.[25] However, all the series became stationary at the first difference.[26] These

results indicate that all the variables are I(1), i.e.,

integrated of degree one at 5 percent level**.**

Table 1
Augmented Dickey-Fuller Unit Root Test

Variable	Level		First difference	
	t-statistic	Critical value at 5% level	t-statistic	Critical value at 5% level
$\ln Y_t$	0.498595	-2.957110	-3.075643	-2.967767
$\ln E_t$	-2.320373	-2.957110	-4.521891	-2.986225
$\ln K_t$	-1.967084	-2.960411	-3.161575	-2.960411
$\ln L_t$	-0.592292	-2.960411	-3.413834	-2.960411

Note: t-statistic greater than the critical value indicates failure to reject the null hypothesis of non-stationarity

5.2 Bounds Test for Cointegration

Since none of the series is I(2), the bounds test for cointegration can be used. Therefore, the Unrestricted ECM given in Eq. (3) is estimated using OLS, and then the restricted form is estimated in order to calculate the F-value (Wald-test). Based on the estimation results, the calculated F-statistic is found to be (5.1182) which is greater than the 5 percent UCB (4.35). Thus the null hypothesis of no cointegration is rejected. This process is repeated for the models given in equations 5, 6 and 7. As reported in Table 2, the results support the hypothesis that all the variables are cointegrated.

Table 2
Results of Bounds Testing to Contegration

Equation	F-Statistic (Calculated)	Decision
$F_Y(Y_t/E_t, K_t, L_t)$	5.1182**	Cointegration
$F_E(E_t/Y_t, K_t, L_t)$	3.8697*	Cointegration
$F_K(K_t/E_t, Y_t, L_t)$	4.6565**	Cointegration
$F_L(L_t/E_t, K_t, Y_t)$	5.9052***	Cointegration
At 1%: Lower bound critical = 4.29 and Upper bound critical value = 5.61		
At 5%: Lower bound critical = 3.23 and Upper bound critical value = 4.35		
At 10%: Lower bound critical = 2.72 and Upper bound critical value = 3.73		

Note: The asterisks ***, ** and * denote the significance at the 1, 5 and 10 percent level, respectively.

Source: Pesaran et al. (2001): Table CI(iii) Case III: Unrestricted intercept and no trend. Number of regressors $k = 3$

5.3 Estimation of Long-Run Elasticities

The existence of cointegration relationship implies the existence of a long run relationship between the variables expressed in Eq. (8). The results of estimating Eq. (8) are given in Table A2 in the appendix. Based on these estimates, the long-run elasticities are calculated using delta method (see for example, Baraizini et al., 2013), and they are reported in Table 3.

Table 3
Estimated Long-Run Coefficients Using
ARDL (2,0,4,1)

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
$\ln E_t$	0.84902	0.16680	5.0901 [0.000]
$\ln K_t$	0.30238	0.13169	2.2961 [0.034]
$\ln L_t$	0.37279	0.12821	2.9076 [0.009]
Constant	-4.5891	1.7090	-2.6852 [0.015]

Dependent variable is $\ln Y_t$

As shown in the above Table, the coefficients have positive signs as expected by the economic theory. Moreover, β_1 and β_3 are significant at one percent level while β_2 is significant at 5 percent level. In particular, a one percent increase in energy consumption leads to 0.85 percent increase in GDP. Similarly, a one percent increase in capital stock causes GDP to increase by 0.30 percent. Finally, a one percent increase in labor results in 0.37 percent increase in GDP. The long run model is given by:

$$\ln (Y_t) = -4.5891 + 0.84902 \ln E_t + 0.30238 \ln K_t + 0.37279 \ln L_t \qquad (14)$$

These results are not totally consistent with the findings of Lee and Chang (2008), but this is not unexpected for a number of reasons; not the least is differences in the type of the data set used in each study, the time span of both studies, the definition of the variables and the econometric methods used in the studies. In contrast to our study which uses time series data over the period 1980-2012, lee and Chang (2008) use panel data set over the period 1971-2002. Moreover, lee and Chang use the figures of labor force and real gross capital formation as provided the World Bank, while our study uses compensation of employees as a proxy of labor and it uses capital formation figures to generate capital stock figures using the ICOR method described above. Finally, Lee and Chang utilize Panel data techniques to test for unit root, cointegration and Granger causality compared with using ARDL and Granger causality in the context of time series analysis as in our study. Still, except for the elasticity of output with respect to capital which is found to be negative in Lee and Chang (-0.01), the other two elasticities are consistent with our results in terms of the sign (with respect to energy and labor, the elasticities are 0.67 and 0.06, respectively).

5.4 Estimation of Short-Run Elasticities

Short run results are found by estimating the error correction representation of Eq. (9) and they are reported in Table A3 in the appendix. As expected, short run elasticities are smaller than long run elasticities. Empirical evidence indicates that energy consumption affects GDP positively and is significant at one percent level. A one percent increase in energy consumption leads to 0.29 percent increase in GDP. Results also show that capital stock affects GDP positively and is significant at 1 percent level. A one percent increase in capital stock increases GDP by 0.24 percent. Finally, labor affects GDP positively and significantly at one percent level. A one percent rise in labor causes an increase in GDP by 0.28 percent. Moreover, the coefficient of lagged error correction term ECT_{t-1} has the correct sign (negative) and is significant at 1 percent level. This confirms the established long run relationship between the variables. Additionally, the value of the coefficient of ECT_{t-1} can be interpreted as the speed of adjustment or convergence towards long run equilibrium. More specifically, about 34% of disequilibrium from the past year will be corrected in the next year, put it another way, adjustment following a shock towards long run equilibrium takes around 2.9 years.

5.5 Granger Causality Test

To test for the existence and the direction of Granger causality, the VECM equations (9 to12) are estimated and the results are presented in Table 4. Starting with the first equation in the VECM model, it can be seen that the independent variables are statistically significant implying the existence of a short run causality running from energy, capital and labor to GDP. For the second equation, the results indicate that there is a short run causality running from GDP and labor to energy. The results for the third equation indicate the absence of short run causality running from GDP, energy or labor to capital. Finally, for the fourth equation, short run causality is running from GDP, energy and capital to labor. To summarize, there is a bi-directional causality between energy and GDP as well as a bi-directional causality between labor and GDP and a uni-directional causality form capital to GDP. Also a bi-directional causality between energy and labor can be observed. Finally, a uni-directional causality is running from capital to labor. In addition to that, the coefficients of the error correction terms ECT_{t-1} have the correct sign and are statistically significant for all the VECM equations, implying the existence of a long run bi-directional causality between the variables. The coefficients are - 0.34225, -0.24539, -0.36695 and -1.5626 for the equations (9 to 12), respectively. Except for the energy equation which is significant at 10 percent, the other three equations exhibit significance at one percent level. Based on the values of these coefficients the speed of adjustment or convergence towards long- run equilibrium can be calculated as done earlier for Eq. (9). The results concerning causality between energy and GDP are consistent with Chontanawat et al. (2006) and Farhani and Ben Rajeb (2012). However, results are in contrast with Shahateet (2014); this might be justified by the inability of the bivariate model employed by Shahateet (2014) to reveal indirect channels of causation as discussed above.

Table 4

Granger-Causality Test

Direction of causality				
Dependent variable	**Short-run Granger causality t-statistic**			**Long-run Granger causality t-statistic**
	$\sum \Delta \ln Y$	$\sum \Delta \ln E$	$\sum \Delta \ln K$	$\sum \Delta \ln L$	ECT_{t-1}
$\Delta \ln Y$	-	3.9277 [0.001]***	2.9994 [0.007]***	4.0243 [0.001]***	-0.34225 [0.001]***
$\Delta \ln E$	4.0543 [0.001]***	-	-0.81211 [0.426]	-2.6411 [0.015]**	-0.24539 [0.088]*
$\Delta \ln K$	1.4313 [0.166]	0.011604 [0.991]	-	1.4371 [0.164]	-0.36695 [0.001]***
$\Delta \ln L$	4.0973 [0.001]***	-2.4228 [0.028]**	2.3082 [0.035]**	-	-1.5626 [0.000]***

Note: The asterisks ***, ** and * denote the significance at the 1, 5 and 10 percent level, respectively.

5.6 Diagnostic Tests

Statistical diagnostic tests are applied to examine model specification and functional forms. As shown in Table 5, the diagnostic tests show that the model passed successfully the tests of serial correlation, functional form, normality and heteroscedasticity. The empirical evidence shows that no serial correlation exists, the functional form of the model is well specified, the residual term is normally distributed and the null of homoscedasticity is not rejected.

To test the stability of parameters, cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) were used. As shown in Figures 1and 2, all values lie within critical bounds of 5 percent. This asserts the stability of short run and long run parameters.

Table 5
Diagnostic Tests

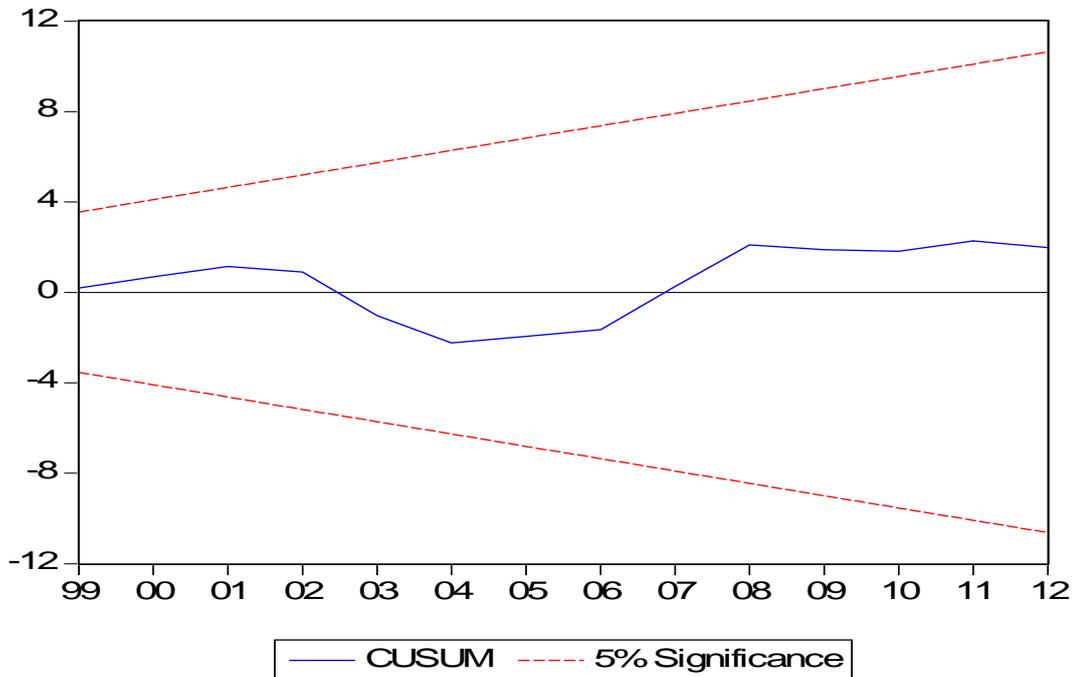| Diagnostic Test	Test Statistic [Prob. values]
Serial correlation	$F(1,17) = 0.0047613[0.946]$
Ramsey's RESET test	$F(1,17) = 0.18038[0.676]$
J-B Normality test	$\chi^2 (2) = 0.084044[0.959]$
Heteroscedasticity test	$F(1,27) = 0.71462[0.405]$

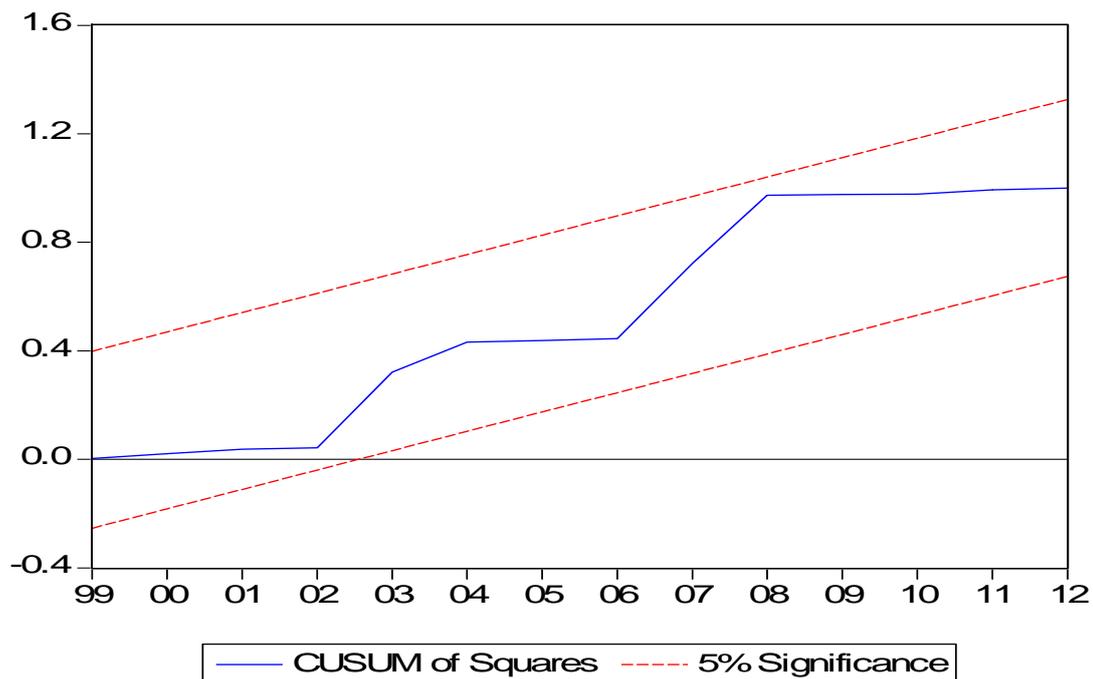**Figure 1: Plot of Cumulative Sum of Recursive Residuals**

Figure 2: Plot of Cumulative Sum of Squares of Recursive Residuals

6. Conclusion and Policy Implication

This paper employs ARDL bounds test to cointegration to examine the short-run and long-run relationship between energy consumption and economic growth in a multivariate framework in Jordan. It also employs Grange-Causality to test for the existence and direction of causality between economic growth and energy consumption in Jordan. A neo-classical aggregated production function is estimated assuming that output is a function of energy, capital and labor. The estimates of long-run elasticities of output with respect to energy, capital and labor are 0.85, 0.30 and 0.37, respectively. While, the short-run estimates are 0.29, 0.24 and 0.28, respectively. Granger-Causality test demonstrates a *positive* bi-directional relationship between energy consumption and economic growth supporting the feedback hypothesis; under this hypothesis energy consumption and real GDP are determined together; therefore, any energy conserving policy (which imposes a structural reduction in the demand for energy) would retard economic growth in Jordan.

Acknowledgments

Appendix

Table A1: Summary of Some of the Studies on Energy-Growth Consumption

Author(s)	Country/Countries	Period of the study	Type of data	Methodology	Direction of Causality
Baranzini et al. (2013)	Switzerland	1950-2010	Time series	ARDL and Granger causality	Real GDP ⟶ Electricity consumption Real GDP ⟷ Heating oil
Shaari et al. (2012)	Malaysia	1980-2010	Time series	Cointegration and Granger causality	Oil - - - - GDP Coal - - - - GDP GDP ⟶ Electricity Gas ⟶ GDP
Landolsi et al. (2011)	Tunisia	1971-2009	Time series	Cointegration and Granger causality	Economic ⟶ growth Energy
Magazzino (2011)	Italy	1970-2009	Time series	Vector auto regressive (VAR), vector error correction (VEC) and Granger causality	Energy ⟶ GDP (in the short run) Energy ⟷ GDP (in the long run)
Tsani (2010)	Greece	1960-2006		Toda and Yamamoto	Energy ⟶ real GDP (at aggregated level) Energy ⟷ real GDP (industrial sector) Energy ⟷ real GDP (residential sector) Energy - - - - real GDP (transportation sector)
Yazdani and Faaltofighi (2013)	Some oil exporter countries (Iran and Saudi Arabia) and some oil importers (Turkey, South Korea, Malaysia, India and Pakistan)	1980-2007	Panel data	Granger causality and panel fully modified ordinary least squares	Energy ⟶ GDP (in oil exporting countries) GDP ⟶ Energy (in oil importing countries)
Hossein et al. (2012)	OPEC countries	1980-2008	Time series[27]	Cointegration and Granger causality	Income ⟶ Energy (in the short run, in Iran, Iraq, Qatar, United Arab Emirates and Saudi Arabia) Energy ⟶ Income (in the short run, in the rest of OPEC countries) Energy - - - - Income (in the long run, in any of the OPEC countries) Economic growth - - - - energy price (for Qatar, Saudi Arabia and Nigeria)

Naryan and Popp (2012)	93 countries (Western Europe, Asia, Latin America, Middle East, Africa and G6 countries excluding Germany)	1980-2006	Panel data	Panel error correction and panel Granger causality	Energy - - - - Real GDP (At individual country level: for most countries)[28] Energy ⟶ Real GDP (At individual country level: causality is negative for rest of the countries)[29] Energy ⟶ Real GDP (At panel level: Western Europe, Asia, Latin America, Africa, G6, and the globe. Causality is positive only for Asia, Africa, and the globe) Energy ⟶ Real GDP (negative long run causality for the G6 panel)

Notes: X ⟶ Y means that the causality runs from X to Y
          X ⟷ Y means that the bi-directional causality exists between X and Y
          X - - - - Y means that no causality exists between X and Y
          X and Y refer to the variables in column 6 in the Table.

Table A2: Autoregressive Distributed Lag Estimates: ARDL(2,0,4,1) Selected Based on the Schwarz Bayesian Criterion

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
$\ln Y_t\,(-1)$	0.29289	0.15269	1.9182[0.071]
$\ln Y_t\,(-2)$	0.36486	0.10024	3.6399[0.002]
$\ln E_t$	0.29058	0.073981	3.9277[0.001]
$\ln K_t$	0.23836	0.079469	2.9994[0.008]
$\ln K_t\,(-1)$	0.0019649	0.12418	.015823[0.988]
$\ln K_t\,(-2)$	-0.33836	0.12376	-2.7340[0.014]
$\ln K_t\,(-3)$	-0.0025032	0.1235	-.020268[0.984]
$\ln K_t\,(-4)$	0.20403	0.085658	2.3819[0.028]
$\ln L_t$	0.27661	0.068734	4.0243[0.001]
$\ln L_t\,(-1)$	-0.14902	0.090053	-1.6548[0.115]
α_0	-1.5706	0.61327	-2.5611[0.020]

R-Squared: 0.99899   R-Bar-Squared: 0.99843   DW-statistic: 1.9322

Table A3: Error Correction Representation for the ARDL (2,0,4,1) Selected Based on

the Schwarz Bayesian Criterion

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
$\Delta \ln Y_t(-1)$	-0.36486	0.10024	-3.6399[.002]
$\Delta \ln E_t$	0.29058	0.073981	3.9277[.001]
$\Delta \ln K_t$	0.23836	0.079469	2.9994[.007]
$\Delta \ln K_t(-1)$	0.13684	0.082361	1.6614[.112]
$\Delta \ln K_t(-2)$	-0.20152	0.071213	-2.8299[.010]
$\Delta \ln K_t(-3)$	-0.20403	0.085658	-2.3819[.027]
$\Delta \ln L_t$	0.27661	0.068734	4.0243[.001]
$\Delta \rho_0$	-1.5706	0.61327	-2.5611[.019]
ECT_{t-1}	-0.34225	0.10179	-3.3624[.003]

Dependent variable is $\Delta \ln Y_t$ ECT_{t-1}: first lagged error correction ter

NOTES

(1) Interested readers may consult Stern (1993) for a detailed discussion of the views of ecological economists and neoclassical economists about energy and its role in the production process. Lee and Chang (2008) provide a useful discussion in this regard.

(2) These hypotheses are discussed in detail in section 2.

(3) This study comes at a time during which energy is one of the hottest issues in Jordan. On one hand, fluctuations in the world oil market had severe impact on the budget because of the high dependency on energy imports. On the other hand disruptions of Egyptian gas supplies caused a significant rise in the cost of generating electricity.

(4) Among the authors who took care about the sign of causality are Sweidan (2102), Narayan and Popp (2012), Narayan et al. (2010), Tsani (2010) and Payne (2010b).

(5) Ozturk (2010) and Payne (2010a, b) provide an extensive review of such studies.

(6) This does not mean by any means that multivariate framework was not utilized previously. Stern (1993, 2000) discusses the merits of using multivariate framework to investigate energy consumption and economic growth nexus. Stern, in addition to other authors, uses labor and capital in addition to energy in his analysis. Studies of this kind are called by Lee and Chang (2008), production side (or aggregate production function) studies

(7) He also recommends the use of two-regime threshold cointegration models, panel data approach and multivariate models as well as the inclusion of variables such as carbon dioxide emissions, population, exchange rates and interest rates.

(8) Table A1 summarizes some of these studies.

(9) Refer to Table A1 for a list of the names of the countries.

(10) They consider energy prices as third variable in addition to energy consumption and economic growth.

(11) The panels are divided on regional basis as follows: Western Europe, Asia, Latin America, Middle East, and Africa. Two more panels were constructed on a non-geographical basis; namely, G6 panel consisting of the six industrialized countries, excluding Germany, and a global panel, consisting

of all the 93 countries.

(12) Although the data set can be treated as a panel/pooled data set, however Ozturk, and Acaravci (2011) choose not to utilize panel/pool data techniques; rather they analyze each country in separation from the rest of the countries.

(13) Within a bivariate framework, two variables are used in this study; namely, GDP per capita and electricity consumption per capita.

(14) It seems that Shahateet (2014), in tandem with Ozturk and Acaravci (2011), does not use panel data methods in his analysis; rather he examines every country in isolation from the other countries. He also recommends the inclusion of other important variables in the determination of economic growth, such as labor and capital. Interestingly, our paper does include them.

(15) The two variables used in their study are final energy consumption in thousand tones of oil equivalent (ktoe) divided by population and real GDP in US dollars using Purchasing Power Parities (PPPs) divided by population.

(16) They classify the countries into four income groups; low income, lower middle income including Jordan, upper middle income and high income countries. To study the relationship between energy consumption and economy growth (GDP), they use energy consumed in kg of oil equivalent per capita and GDP per capita data with constant 2000 US$.

(17) The merits of Cobb-Douglas functional form are discussed extensively in Lee and Chang (2008). This log-linear model has the virtue of interpreting the coefficients as elasticities.

(18) As mentioned earlier, this methodology is recommended by Ozturk (2010). Among the authors who use this methodology are Shahateet (2014), Shahbaz and Dube (2012), Sweidan (2012), Tang and Tan (2012), Ozturk and Acaravci (2011) and Squalli (2007).

(19) See Squalli (2007) among others

(20) The appropriate lag length is usually determined with the assistance of the Akaike Information Criterion and/or the Schwarz Bayesian Criterion. In our case, the letter one is used.

(21) The ARDL procedure is conveniently included in the Microfit software produced by Oxford University Press: http://global.oup.com/uk/microfit/

(22) The ECT_{t-1} term will be excluded from any equation of the VECM model if the variables were not co-integrated. However, our VECM model will not exclude the error correction from any of its four equations since the equations (4,5, 6 and 7) are co-integrated at the levels of 5 percent, 10 percent, 5 percent and 1 percent, respectively.

(23) According to the Ministry of Minerals and Natural Resources (MEMR), consumption of primary energy includes consumption of crude oil and the oil products, natural gas, renewable energy and imported electricity

(24) Figures on capital and employees' compensation are available only for 2011. For the purposes of our analysis, it is assumed that these figures did not change in 2012.

(25) These results were obtained assuming the existence of intercept. The test was redone a couple of times; once assuming intercept and trend and once assuming neither trend nor intercept. Under the intercept and trend assumption, $\ln E_t$ was stationary at 1 percent level. However, under the assumption of neither trend nor intercept, none of the series was stationary. The unit root test was also performed using Phillips-Perron method and the same conclusions were reached.

(26) Note that the first difference of the logarithm of a variable is a close approximation of the percentage change or the growth rate of the variable.

(27) They treat each country separately and not in the context of a panel data structure.

(28) For a list of the names of the countries, see Table 10 in Narayan and Popp (2012).

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استهلاك الطاقة والنمو الاقتصادي في الأردن باستخدام نموذج الانحدار الذاتي للفجوات الزمنية الموزعة

سامح العجلوني *

ملخص

يهدف هذا البحث إلى دراسة أثر الطاقة المستهلكة على النمو الاقتصادي في الأردن إضافة إلى التحقق من وجود علاقة سببية بين الطاقة المستهلكة والنمو الاقتصادي واتجاه هذه العلاقة في الأردن باستخدام بيانات السلاسل الزمنية للفترة 1980–2012. ولتحقيق الهدف الأول فقد تم تقدير دالة الإنتاج الكلي بصيغتها اللوغارتمية، باستخدام نموذج الانحدار الذاتي للفجوات الزمنية الموزعة، باعتبارها دالة في كل من الطاقة المستهلكة ورأس المال والعمل كعوامل إنتاجية. وأسفرت نتائج التقدير عن القيم الآتية للمرونات الإنتاجية طويلة الأجل وقصيرة الأجل بالنسبة لكل من العناصر الإنتاجية آنفة الذكر: بلغت قيم المرونات طويلة الأجل 0.85، 0.30 و0.37 بالنسبة للطاقة المستهلكة ورأس المال والعمل على الترتيب، وبالمقابل فإن قيم المرونات قصيرة الأجل قد بلغت 0.29، 0.24 و0.28 وفقا للترتيب السابق. أما بالنسبة لاختبار جرانجر للسببية فقد أظهر وجود علاقة موجبة باتجاهين ما بين الطاقة المستهلكة والنمو الاقتصادي وهذا يؤكد فرضية التغذية الراجعة، والتي مفادها أن الطاقة المستهلكة والنمو الاقتصادي يتحددان سوية وبالتالي فإن انتهاج سياسات لترشيد استهلاك الطاقة قد تؤدي إلى تباطؤ في النمو الاقتصادي في المملكة.

الكلمات الدالة: الأردن، النمو الاقتصادي، الانحدار الذاتي للفجوات الزمنية الموزعة، سببية جرانجر.

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