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The causal relationship between energy consumption and economic growth in Lebanon

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HIGHLIGHTS

- ► We investigate the energy-GDP nexus for Lebanon.
- ► Evidence of a bidirectional relationship both in the short- and the long-run is found.
- ► Reducing outages by expanding electric capacity should thus be prioritized.
- ► The energy plan calling for a 5% reduction in energy consumption needs to be revised.
- ► Development of domestic energy sources will help in mitigating energy supply shocks.

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ABSTRACT

This paper investigates the dynamic causal relationship between energy consumption and economic growth in Lebanon over the period 1980–2009. Within a bivariate framework, imposed on us due to data limitations, and in an effort to increase the robustness of our results, we employ a variety of causality tests, namely, Hsiao, Toda-Yamamoto, and vector error correction based Granger causality tests. We find 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. From a policy perspective, the confirmation of the feedback hypothesis warns against the use of policy instruments geared towards restricting energy consumption, as these may lead to adverse effects on economic growth. Consequently, there is a pressing need to revise the current national energy policy that calls for a 5% energy conservation target. Also, to shield the country from external supply shocks, given its substantial dependence on energy imports, policymakers should emphasize the development of domestic energy resources. Further, the most pertinent implication is that relaxing the present electric capacity shortages should be made a national priority, in view of its potential positive effect on the economy.

1. Introduction

Since the seminal study of Kraft and Kraft (1978), probably motivated by the oil price shock of 1973, the relationship between energy consumption and economic growth, aka the energy-GDP nexus has been abundantly studied. Examining the energy-GDP nexus is of interest mainly due to its far-reaching policy implications. The type of relationship can be classified into four testable hypotheses. First, if a unidirectional relationship running from energy consumption to economic growth is found, then the economy is said to be an energy dependent one and any energy policy encouraging conservation[1] might adversely affect economic growth. This is known as the growth hypothesis. Second, if the inverse relationship is found, i.e. causality running from GDP to energy consumption, then energy policy will not affect growth, but changes in GDP will directly result in changes in energy consumption. This is known as the conservation hypothesis. Third, a bidirectional or mutual relationship confirms what is known as the feedback hypothesis. In the fourth case, no evidence of any relationship between the two variables is found. This is often referred to as the 'neutrality hypothesis.' In the first three cases, national energy and environmental policies must be carefully designed to take the energy-GDP relationship into consideration.

As a result of the growing interest in climate change and the focus of mitigation activities on the energy sector, as well as the rising cost of energy, energy conservation policies have seen a strong come-back in many countries. However, as can be seen from the relationships presented above, at least in one of the cases, such a policy might negatively impact the economy. In this

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[1] Although energy conservation can take different forms, what we are specifically referring to in this paper is a decrease in energy consumption that is not due to improvements in energy efficiency.

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paper, we examine the case of Lebanon for several reasons. First, in spite of the abundance of studies in this field, none has examined the energy-GDP relationship for Lebanon. One study looked at the electricity-GDP relationship and found evidence supportive of the growth hypothesis (Abosedra et al., 2009). A major drawback of this study is that the authors apply the standard Granger causality tests without explicitly testing for the stationarity of the employed variables.

Second, electricity consumers in Lebanon experience extensive power rationing. If our findings support the growth hypothesis, then this rationing would be harming the economy and eliminating or at least reducing the power outages should be high on the national agenda.

Third, the country is vastly dependent on imported energy. If evidence of an energy-dependent economy is found, then the economy would be highly sensitive to external energy shocks, and policymakers should hence prioritize the development of domestic energy resources.

Finally, the Lebanese government has recently (and for the first time) set a 5% energy conservation target as part of its energy policy (Ministry of Energy and Water (MEW) Lebanese Republic, 2010). Consequently, the type of relationship between energy consumption and GDP is of critical importance, since if this relationship runs from energy consumption to GDP then such a policy might have a negative impact on GDP growth. This study, by shedding some light on the role of energy consumption in economic development, aims at providing insights into the abovementioned issues that can serve as a basis for future energy and environmental policies.

The remainder of the paper is structured as follows. Section 2 provides a brief review of the literature. In Section 3 we present an overview of the energy sector and the economy in Lebanon, highlighting the country's particularities. Section 4 outlines the model and econometric methodology employed, followed by a presentation and discussion of the results in Section 5. Finally, in Section 6, we offer some concluding remarks on the results and some policy implications.

2. Literature review

Some researchers have chosen to examine single countries, while others have studied several countries simultaneously in a panel data analysis framework. Typically, aggregate energy consumption is used as a proxy for energy consumption, but sometimes more disaggregated levels (e.g. residential, commercial, etc.) or specific energy sources have been examined (coal, nuclear, etc.). The main trend tends to be a bivariate analysis; the two variables being energy consumption and GDP (see inter alia, Altinay and Karagol, 2004; Ghosh, 2002; Soytas and Sari, 2003; Yoo, 2005). Bivariate models are especially attractive in that they can be used for countries that suffer from a complete lack of data on some variables of interest (Zachariadis, 2007), as is typical in many developing countries. In a recent survey, Payne (2010) notes that 26 of the 35 studies surveyed employ bivariate models. Some other studies have conducted multivariate analyses based on theoretical considerations such as demand or production functions. The former typically includes the price of energy as a third variable (see inter alia, Asafu-Adjaye, 2000; Bloch et al., 2011; Masih and Masih, 1997, 1998) and the latter usually includes measures for capital and labor (see inter alia, Apergis and Payne, 2009a, 2009b; Oh and Lee, 2004; Stern, 1993, 2000; Wolde-Rufael, 2009).

Recently, some studies have tried to find linkages with the environmental pollution-economic growth nexus usually investigated within the ''Kuznets curve'' framework, and have thus included emissions as a third variable in their model (see inter alia, Menyah and Wolde-Rufael, 2010; Nasir and Rehman, 2011; Pao and Tsai, 2010).

Generally speaking, existing studies have yielded conflicting results even for the same country. Researchers have attributed this divergence to differences in model specifications, sample periods, and estimation and testing methodologies (Apergis and Payne, 2011). An exhaustive review of the literature can be found in Payne (2010) or Ozturk (2010). Overall, these reviews highlight the importance of using large samples and multivariate models, when data availability allows that.

Besides the immediate policy implications of the energy-GDP nexus, some researchers have gone one step further in their policy recommendations, by concluding which countries can successfully implement the Kyoto Protocol without hurting their economic growth and which ones cannot (Lee, 2006). Also, some researchers suggest that energy resource endowment might have an impact on the direction of causality. For example, Wolde-Rufael (2009) finds evidence supporting the growth hypothesis in oil rich countries, while Al-Iriani (2006), in contrast, finds support for the conservation hypothesis for the Gulf Cooperation Council (GCC) countries. Examining a group of African countries, Eggoh et al. (2011) find evidence that the energy consumption-economic growth relationship is different for energy exporters versus energy importers.

A few studies suggest that countries in comparable stages of development can adopt similar energy policies and strategies, because the causal relationship between energy consumption and growth depends in part on the country's stage of development. Apergis and Payne (2011) categorize 88 countries into four panels based on the World Bank income classification and conduct a multivariate panel analysis. They conclude that the relationship between electricity consumption and growth is a function of a country's stage of development. Bildirici and Kayikci (2012), in their turn, divide the Commonwealth of Independent States into three groups based on the income per GDP level and investigate the electricity-growth nexus by group. Similarly to Apergis and Payne (2011), they find that the electricity-GDP relationship does differ across groups.

In contrast, other studies have suggested that the energy-growth nexus is country specific, and hence one cannot generalize to include countries in the same stage of development or in the same geographical region. Akinlo (2008) explores the energy-growth relationship in 11 sub-Sahara African countries, and concludes that African countries cannot adopt the same energy conservation policies, but rather each country needs to develop its own energy strategy based on its peculiar characteristics. Similarly, Acaravci and Ozturk (2010) find different energy-growth relationships for each member of a set of 19 developed European countries. The results for four Asian developing countries investigated by Asafu-Adjaye (2000) and eight newly industrialized Asian countries investigated by Chiou-Wei et al. (2008) also confirm the hypothesis that the energy-growth relationship is not determined by the level of development in a country.

As noted earlier, in the existing body of the literature only one study investigates the electricity-GDP relationship for Lebanon (Abosedra et al., 2009). It is very likely that the unavailability of data was the main reason for excluding Lebanon from large panel studies especially when these are conducted within a multivariate framework (see e.g. Apergis and Payne, 2011; Costantini and Martini, 2010; Huang et al., 2008; Joyeux and Ripple, 2011; Lee and Chang, 2007; Mahadevan and Asafu-Adjaye, 2007; Narayan and Smyth, 2009; Narayan et al., 2010; Ozturk and Acaravci, 2011; Ozturk et al., 2010; Sharma, 2010).

3. Economic growth and energy consumption profiles

Lebanon's economy was hard-hit by the 15-years civil war (1975–1990) and still suffers from occasional economic downturns caused by political instabilities. Its GDP in 2010 was $39 billion (current USD) and its GDP per-capita[2] was $10,041 (2010 USD) (WDI, 2012; International Monetary Fund (IMF), 2012a). Lebanon is, hence, considered to be a developing upper middle income country (WDI, 2012). Despite the global recession, the real GDP growth between 2009 and 2010 stood at 7.5% compared with 3.8% for the MENA region (International Monetary Fund (IMF), 2012a). It is worth noting here that the Lebanese real GDP has grown at a faster pace than the regional (MENA) real GDP since 2007 (International Monetary Fund (IMF), 2012a). Lebanon has the highest Government gross debt in the region, 137.1% of GDP in 2011, and is ranked 5th worldwide in highest debt to GDP ratio (Central Intelligence Agency (CIA), 2011).The economy is mainly service oriented with the service sector constituting 72% of GDP, while industry and agriculture make up 21% and 6% of GDP, respectively (WDI, 2012).

To date, Lebanon has not uncovered any fossil fuel resources[3] and hence relies on imports for the vast majority of its energy needs. Energy imports are mainly gasoline, diesel, and fuel oil, with insignificant amounts of coal imported for industrial consumption in cement manufacturing. The share of fossil fuel is 95.9% of total energy consumption (WDI, 2012) which for 2009 was around 5 million tons of oil equivalent or 1.3 t of oil equivalent per person (Climate Analysis Indicators Tool (CAIT), 2012). Its GDP per unit of energy use (7.5 constant 2005 PPP $ per kg of oil equivalent) for 2009 is very similar to that of France (7.4). This low energy intensity reflects the dependence of the economy on the services sector (services constitute 72% and 79% of GDP, respectively, for Lebanon and France), which has a low energy intensity relative to other sectors (WDI, 2012). In contrast, the Arab countries have a much higher energy intensity (4.85 constant 2005 PPP $ per kg of oil equivalent) and a much smaller services sector (44% of GDP) (WDI, 2012).

The only domestic energy source is in the form of hydro power plants, which generated around 3% of the total electricity in 2009, accounting for a mere 0.8% of total energy use (WDI, 2012). There is modest potential for expansion of the hydro sector from 274 MW of currently installed capacity to around 394 MW (Ministry of Energy and Water (MEW) Lebanese Republic, 2010).

Unlike other similar developing countries, Lebanon enjoys a high degree of electrification (99.9%); almost all households are connected to the electricity network (World Bank, 2009). Unfortunately, Lebanese electricity consumers in 2012 still suffer from extensive rationing and unscheduled power cuts reaching 13 h per day in some cities (World Bank, 2009), and hence have to rely on backup generators during those blackout periods. Typically, rationing hours are unevenly distributed between cities, differ from day to day, and the consumer cannot get any advance information on the rationing schedule (Dagher and Ruble, 2010). So far, the utility has been increasingly unable to satisfy electricity demand that is crucial for the country's development (Dagher and Ruble, 2011). Lebanon ranked 7th in value lost due to electrical outages in 2009, while Syria, the only other MENA country on that list, ranked 8th (WDI, 2012). In view of the status of the electricity sector, we believe that electricity consumption data do not reflect the true picture, due to unsatisfied demand that cannot be accurately measured. Hence, the results of studies that use the electricity consumption series such as Abosedra et al. (2009) should be interpreted with caution.

Looking at the basic statistics, one might wrongfully conclude that Lebanon, with its low aggregate emissions, is on the right path of controlling its greenhouse gas emissions. For example, in 2008 Lebanon ranked 85th in greenhouse gas emissions with a total of 17.7 $MtCO_2e$, and ranked 78th for the same year in per-capita emissions which amounted to 4.3 tCO_2e per person (Climate Analysis Indicators Tool (CAIT), 2012). However, examining the data further, one finds that although regionally Lebanon's per-capita emissions are at the lower end (Qatar ranks 1st and Kuwait 3rd globally in per-capita emissions), globally many countries with higher aggregate emissions rank better in per-capita emissions. For example, India which ranks 5th worldwide (i.e. has much higher aggregate emissions compared to Lebanon) has substantially lower per-capita emissions of 1.3 tCO_2e per person (Climate Analysis Indicators Tool (CAIT), 2012). In terms of carbon intensity of energy use, Lebanon ranks 5th worldwide at 3.38 tCO_2e/tons of oil equivalent (Climate Analysis Indicators Tool (CAIT), 2012).

Lebanon ratified the Kyoto Protocol in 2006, but being an Annex A country did not take on any binding commitments to reduce greenhouse gas emissions. However, it is expected that developing countries such as Lebanon will have to actively participate in the mitigation efforts at some point. Consequently, the results of this study will have direct bearing on the level of commitment that Lebanon can make. In 2010, the Ministry of Energy and Water, and for the first time, announced a national energy plan that included a 5% reduction in energy consumption. Such policies need to consider the potential causal linkages between energy consumption and economic growth. In this study, we attempt, through the investigation of the energy-GDP nexus, to determine whether such a commitment could hurt the economy.

Fig. 1 presents the time plots of GDP (measured on the right axis) and energy consumption (measured on the left axis) for the period 1980–2009. The real (constant 1990 prices) GDP series in billions of domestic currency were obtained from the International Monetary Fund database (International Monetary Fund (IMF), 2012b) and the energy consumption data measured in quadrillion Btu were taken from the Energy Information Administration database (Energy Information Administration (EIA), 2012). Both variables were transformed into natural logs. Visual inspection of the graph indicates positive correlation between the two series, with the exception of the last couple of years.

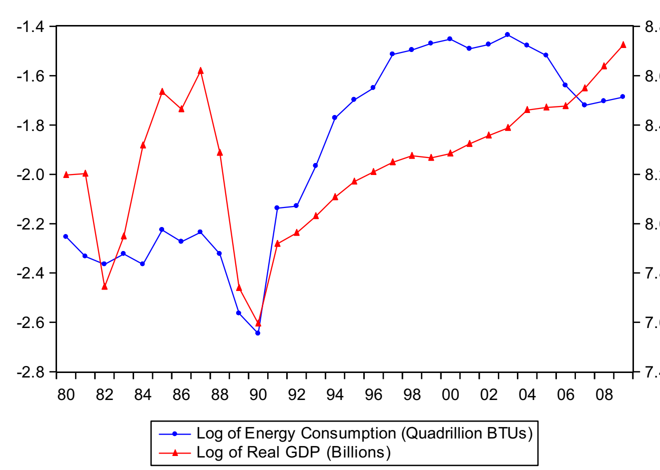

Fig. 1. Energy consumption and real GDP in Lebanon, 1980–2009.

[2] All per-capita figures are to be used with caution, because no official census has been taken since 1932. Lebanon's population as of 2009 is estimated at 4,197,000 (WDI, 2012).

[3] The Lebanese cabinet has recently passed a law allowing offshore exploration for gas. Successful exploration could radically change the country's energy prospects (Economist Intelligence Unit (EIU), 2011).

Given Lebanon's huge dependence on energy imports, its increasing inability to satisfy national electricity demand, the rise in global energy prices, and the ongoing pressure for developing countries to take on binding commitments to reduce GHG emissions, Lebanon faces several challenges in the near future. A good understanding of the type of causal relationship between energy consumption and economic growth will help in designing and implementing adequate national energy and environmental policies.

4. Econometric framework

This section discusses the econometric procedures undertaken to test the direction of causality between the two variables—energy consumption (hereafter E) and real GDP (hereafter Y) in Lebanon. Despite the well-known advantages of using multivariate models, in this paper we base our analysis on a bivariate model due to the lack of data which is not uncommon in developing countries. Most of the researchers who caution against the use of bivariate models also stress the importance of using large sample sizes, which according to Zachariadis (2007) include more than 35 observations. Our data span the period 1980–2009 resulting in 30 observations, which again are typical for developing countries.

Traditionally, earlier studies used either Granger (1969) or Sims (1972) tests to determine the direction of causality between E and Y. Granger (1988) defines causality as "if y_t causes x_t, then x_{t+1} is better forecast if the information in y_{t-j} is used than if it is not used." To determine the direction of causality, a simple Wald test in an unrestricted VAR setting is applied to a group of coefficients to test whether they are jointly significant or not. For example, in Eq. (1) if $\beta_1=\beta_2=\cdots=\beta_M=0$ then GDP does not Granger cause energy consumption, while if the opposite is true then GDP can be said to Granger cause energy consumption. Similarly, in Eq. (2) we test whether the group of μ coefficients are jointly significant or not to conclude whether energy consumption Granger causes GDP or not. M, N, R, and S are usually determined based on a lag selection criterion such as the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC)

$$E_t=\alpha+\sum_{i=1}^{M}\beta_i Y_{t-i}+\sum_{j=1}^{N}\gamma_j E_{t-j}+u_t \quad (1)$$

$$Y_t=\delta+\sum_{i=1}^{R}\mu_i E_{t-i}+\sum_{j=1}^{S}\rho_j Y_{t-j}+\nu_t \quad (2)$$

where u_t and ν_t are white noise error processes. This simple Wald test, however, is only valid if all variables are stationary (Granger, 1969; Granger and Newbold, 1974). Otherwise, the test will have nonstandard distributions (Sims et al., 1990; Toda and Phillips, 1993), and hence other tests must be used. In the context of studying the energy-GDP relationship, it has been frequently found that either one or both of the variables of interest contain a unit root. This explains the shift from using Granger's test in earlier studies to using alternative tests (such as Hsiao, Toda-Yamamoto, or Granger causality on a vector error correction model (VECM)) since the 1980s. Another drawback of Granger's test, is that the causality results are very sensitive to the selected lag length (Chontanawat et al., 2008).

In response to the criticisms regarding the lag length selection under Granger's test, Hsiao (1981) proposed a modified version of the test that uses Akaike's Final Prediction Error (FPE) criterion (Akaike, 1970) to select the lag length of each of the variables. The first step is to determine the number of lags n that minimizes the FPE of Eq. (1) without any Y lags. Once n is set, we start varying the number of lags of the second variable, Y, to find m, the number of lags that minimizes the FPE. The FPEs from both steps (with lags of Y and without) are then compared; if FPE($n,0$) is smaller than FPE(n,m), then we can conclude that GDP does not cause energy consumption and vice versa. A similar procedure is applied to Eq. (2) to find out if energy consumption causes GDP or not by comparing FPE($s,0$) to FPE(s,r). The Hsiao test can be applied regardless of the integration order or cointegration properties of the original variables involved, as long as the variables in their final transformed forms are stationary; some series might need differencing to attain stationarity (Hsiao, 1981).

Toda and Yamamoto (1995), TY hereafter, propose a causality test that involves a modified Wald test on an augmented VAR specification. In the TY causality test, the optimal lag length l is selected based on one of the typical lag selection procedures and then the VAR (l) is augmented by the maximum order of integration of the variables, m, to obtain a VAR($l+m$). Typically, in applications such as ours m ranges between 0–2. Consider the following VAR(l) specification:

$$E_t=\alpha+\beta_1 Y_{t-1}+\cdots+\beta_l Y_{t-l}+\gamma_1 E_{t-1}+\cdots+\gamma_l E_{t-l}+u_t \quad (3)$$

$$Y_t=\delta+\mu_1 E_{t-1}+\cdots+\mu_l E_{t-l}+\rho_1 Y_{t-1}+\cdots+\rho_l Y_{t-l}+\nu_t \quad (4)$$

We then augment each of the two equations with m lags

$$E_t=\alpha+\beta_1 Y_{t-1}+\cdots+\beta_{l+m} Y_{t-l-m}+\gamma_1 E_{t-1}+\cdots+\gamma_{l+m} E_{t-l-m}+u_t \quad (5)$$

$$Y_t=\delta+\mu_1 E_{t-1}+\cdots+\mu_{l+m} E_{t-l-m}+\rho_1 Y_{t-1}+\cdots+\rho_{l+m} Y_{t-l-m}+\nu_t \quad (6)$$

The VAR($l+m$) is now estimated using a seemingly unrelated regression (SUR) procedure. Tests for the significance of coefficients are conducted by ignoring the last m lags added to the VAR. For instance, to study whether Y Granger causes E in the system above, the joint significance of the βs should be examined for the first l terms in Eq. (5). If the null hypothesis $\beta_1=\beta_2=\cdots=\beta_l=0$ cannot be rejected then we conclude that Y does not Granger cause E, and vice versa. Similar steps are followed to test whether there exists a causality relationship from E to Y or not, this time by examining Eq. (6). The test statistic is a Wald statistic having an asymptotic χ^2 distribution with l degrees of freedom.

Unlike Granger's test, the TY approach can be applied to both stationary and non-stationary variables. Moreover, in contrast to the Hsiao test, variables can still be used in levels even if they contain a unit root. By intentionally adding m lags to the VAR(l), the TY procedure avoids any biases related to unit root and cointegration testing and hence increases the robustness of the results. Clarke and Mirza (2006) compare different causality tests and conclude that the TY exhibits more consistent performance and seems to be superior to the pretesting approaches, which include Johansen (1988) and Engle and Granger (1987). Also, the size of the TY test has been found to be acceptable, however, the test has been criticized for being inefficient since it overfits the VAR and consequently suffers from low power (Kuzozumi and Yamamoto, 2000).

To distinguish between the short-run and the long-run relationships between energy consumption and growth, the traditional methodology of testing for unit roots and cointegration must be followed. In case at least one cointegrating relationship was found, then based on the Granger representation theorem, Granger (1988) shows that if a pair of $I(1)$ series are cointegrated, then a causal relationship exists in at least one direction. The dynamic Granger causality can be captured from the vector error correction model derived from the long-run cointegrating relationship (Granger, 1988). Assuming E and Y are found to be cointegrated, then in an effort to capture SR and LR sources of causality between the variables, the VECM of Eqs. (7) and (8) can

Table 1
Unit root test results.

Variables	ADF[a]		PP[b]	
	Constant and trend	Constant	Constant and trend	Constant
E	−1.35 (0.85)	−0.99 (0.74)	−1.66 (0.74)	−1.05 (0.72)
ΔE		−4.67 (0.00)		−4.66 (0.00)
Y	−2.39 (0.38)	0.08 (0.96)	−2.36 (0.39)	−1.73 (0.41)
ΔY		−1.71 (0.41)		−4.14 (0.00)

Notes: Probability values are in parentheses. [a] AIC is used to select the lag length. [b] Barlett kernel is used as the spectral estimation method. Newey–West is used as the bandwidth selection method.

be estimated

$$\Delta E_t = \alpha + \theta ECT_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta E_{t-i} + u_t \quad (7)$$

$$\Delta Y_t = \delta + \varphi ECT_{t-1} + \sum_{i=1}^{p} \mu_i \Delta E_{t-i} + \sum_{i=1}^{p} \rho_i \Delta Y_{t-i} + v_t \quad (8)$$

where *ECT* denotes the error correction term which represents the cointegrating or long-run relationship between the two variables. To test for LR causality in Eq. (7), we test the following null hypothesis $\theta = 0$, if we reject the null then Y Granger causes E in the long-run and vice versa. A similar test can be applied on φ in Eq. (8) to check if E Granger causes Y in the LR or not. Short-run causality from Y to E is detected if the null hypothesis $\beta_1 = \cdots = \beta_p = 0$ can be rejected, otherwise we conclude that Y does not Granger cause E in the SR. Similarly, to check for SR causality from E to Y in Eq. (8), we test if $\mu_1 = \cdots = \mu_p = 0$ or not.

5. Empirical results

To test the stationarity properties of the time series E and Y, the Augmented Dickey Fuller (ADF) and the Philips–Perron (PP) unit root tests are employed. The results reported in Table 1 confirm the presence of a unit root for both GDP and energy consumption at the 10% significance level, but no evidence of a unit root was found for the differenced variables. We thus conclude that both variables are $I(1)$; i.e. their levels are non-stationary but their differences are stationary. The findings for the Lebanese energy consumption variable are in line with those of Narayan and Smyth (2007) who examine the stationarity properties of the energy consumption variable in a multitude of countries. It is important to note here the implications of the unit root properties of the energy consumption variable. Essentially, if E is stationary then innovations in a country's energy consumption have temporary effects and E will return to its trend path, whereas if E is non-stationary then innovations will have permanent effects (Apergis and Payne, 2010; Narayan and Smyth, 2007). Thus, if E follows a non-stationary process, any shock such as one resulting from an energy price shock, will be transmitted to other macroeconomic variables, and given the importance of energy in the economy could potentially have disastrous effects (Apergis and Payne, 2010; Narayan and Smyth, 2007).

We now proceed to test for the presence of a long-run cointegrating relationship, or in other words, the existence of a common trend. The Engle–Granger test confirms that the variables are cointegrated[4] and further proof is provided by the

[4] Note that the null hypothesis of no cointegration is only rejected when GDP is the dependent variable.

Table 2
Cointegration test results.

A. Johansen test		
Number of cointegrating equations	Maximum eigenvalue statistic	Trace statistic
$r=0$	28.67 (0.00)	32.37 (0.00)
$r=1$	3.71 (0.05)	3.71 (0.05)
B. Engle–Granger test		
Dependent variable	*z*-statistic	
Y	−17.68 (0.04)	
E	−12.78 (0.15)	

Notes: Probability values are in parentheses.

Table 3
VECM estimation results.

Cointegrating equations	Cointegrating Eq. (1)	
$Y(-1)$	1.00	
$E(-1)$	−0.23	
	[−5.50]	
C	−8.69	
Error correction	$D(Y)$	$D(E)$
Cointegrating Eq. (1)	−1.14 [−5.77]	−0.54 [−2.10]
$D(Y(-1))$	1.47 [7.76]	0.48 [1.93]
$D(Y(-2))$	0.40 [1.96]	0.19 [0.72]
$D(Y(-3))$	0.74 [4.28]	−0.01 [−0.03]
$D(E(-1))$	−1.13 [−5.24]	−0.46 [−1.66]
$D(E(-2))$	−0.68 [−2.76]	−0.27 [−0.83]
$D(E(-3))$	−0.84 [−3.93]	0.10 [0.37]
C	0.03 [1.61]	0.02 [0.86]

Notes: t-statistics in brackets.

Johansen test based on the trace and eigenvalue statistics. All results are reported in Table 2. We thus have ample evidence of the existence of a long-run relationship between energy consumption and GDP in Lebanon.

Having found evidence of a cointegrating relationship, this implies causality in at least one direction. Following Zachariadis (2007) advice of using multiple causality testing methods when a bivariate model is the only option of investigating the energy-GDP nexus in a developing country, and in order to shed more light on the nature of the causality between E and Y, we will conduct three different causality tests; Granger on a VECM, TY, and Hsiao. Estimation of the VECM yields significant coefficients on the error correction term in both equations (see Table 3), we can hence conclude that there is a bidirectional relationship between E and Y in the long-run. Jointly testing the parameters on the differenced variables in both equations, also confirms the feedback hypothesis in the short-run.

The Hsiao test is applied on the differenced variables since both were found to be $I(1)$. For both steps we went up to the maximum allowed number of lags given the number of observations, which results in a total of 18 lags (9 for each variable). When E is the dependent variable, we find the minimum FPE(n,0) of 0.0172 when $n=9$ lags. Varying lags of Y, we find that the optimal FPE(9,8) is 0.0009. Hence, we conclude that Y Granger causes E. When Y is the dependent variable, step 1 yields a minimum FPE(s,0) of 0.0022 with $s=9$ lags. In step 2, we find the optimal FPE(9,8) to be 0.0002. We thus conclude that E Granger causes Y. Consequently, based on the FPE criterion, there is evidence in support of the feedback hypothesis confirming our earlier results.

The TY test was also applied with a maximum order of integration m equal to 1. The results are in agreement with those from the VECM where a bidirectional relationship was found. As a check for the robustness of the results, we varied the order of lags $(l+m)$ from a minimum of 2 to a maximum of 9, which was the maximum possible given the number of observations, the result, however, did not change. It is important to note here that diagnostic testing for serial correlation, heteroskedasticity, and normality of residuals were carried out on all final specifications to check for the normality and whiteness of residuals.

In summary, the TY, the granger causality on a VECM, and the Hsiao tests all produced identical results confirming the feedback hypothesis.

6. Conclusions and policy recommendations

The aim of this paper is to investigate the existence and direction of the causal linkages between energy consumption and economic growth in Lebanon using time series data for the period 1980–2009. We employ a bivariate model and subject it to a battery of causality tests, namely, Hsiao, TY, and Granger causality on a VECM. We find strong evidence of a bidirectional relationship both in the SR and in the LR. Thus, we may conclude based on our findings that energy is a limiting factor to economic growth in Lebanon. This identified relationship should help policymakers in designing effective energy and environmental policies both in the short- and long-run.

From a policy perspective, the confirmation of the feedback hypothesis warns against the use of policy instruments geared towards restricting energy consumption, as these may lead to adverse effects on economic growth. Given these results, the current national energy plan seems inadequate since it calls for a 5% reduction in energy consumption. Emphasis should be mainly placed on supply side options and energy efficiency improvements rather than on such energy limiting policies. Some currently used demand side management activities by various utilities around the world could be very useful for Lebanon such as the transition from incandescent to compact fluorescent lighting, while others such as the ‘load control’ programs, where utilities can cycle (or even turn off) consumers’ air conditioners during periods of peak demand, could hurt the economy.

Given Lebanon’s extensive dependence on imports for the satisfaction of its energy needs, any supply shock will negatively affect development. To enhance security of supply, Lebanon’s energy policies should focus on diminishing the country’s dependence on external energy sources. The government should thus prioritize the development of domestic energy sources such as the expansion of its hydroelectric power capacity, promoting wind, solar, and geothermal energy, and last but not least push forward in its offshore exploration of natural gas. What exacerbates Lebanon’s sensitivity to external oil shocks is the non-stationarity of its energy consumption. Given its importance to the economy, any shock to energy consumption would be transmitted to different sectors in the economy, which would as a result inherit the non-stationarity (Apergis and Payne, 2010; Narayan and Smyth, 2007).

Further, the most pertinent implication is that relaxing the present electric capacity shortages should be made a national priority, in view of its potential positive effect on the economy. Currently, growth prospects are being hampered by intensive electricity outages and heavy technical losses. Investing in new capacity to relax the electricity supply constraints and reducing the losses can further stimulate economic growth. In addition, any new capacity coming online will immensely increase the supply efficiency, especially that it will be replacing the older less efficient backup generators. This, in turn, could help curb the demand without having any negative effects on the GDP. Moreover, the supply constraint problem is exacerbated by the finding that GDP also granger causes energy consumption, In a rapidly growing economy such as Lebanon, the implication of this finding is that the currently observed high economic growth will lead to a high growth in energy consumption. Consequently, it is critical to meet energy demand if we want to sustain the current growth momentum.

Bivariate models have been repeatedly criticized, because in such an omitted variables setting there is a tendency to under-reject the null of no Granger causality (Lütkepohl, 1982), i.e. it is likely in such a setting not to find any causal relationships. Fortunately, this was not the case in the present study. However, we have to admit that the analysis performed, being constrained by data unavailability, may suffer from other limitations. For instance, we could not discuss the resulting signs and magnitudes of the estimated coefficients, because these are known to be biased and inconsistent as a result of the omitted variables.

The energy-GDP relationship for most countries has been abundantly studied, however, for Lebanon there exists only one study that examines the electricity-GDP relationship. Abosedra et al. (2009) find evidence supportive of the growth hypothesis. A major drawback of this study is that the authors apply the standard Granger causality tests without explicitly testing the stationarity of the employed variables. It is very likely that the unavailability of data was the main reason for excluding Lebanon from large panel studies especially when these are conducted within a multivariate framework (see inter alia, Apergis and Payne, 2011; Costantini and Martini, 2010). Our results seem to be in accordance with the findings of Apergis and Payne (2011) that for the panel of upper middle-income countries there was evidence in support of the feedback hypothesis both in the short- and long-run.

Future research examining Lebanon in a regional panel framework may provide additional insights regarding the impact of oil resources on the relationship between energy consumption and GDP. A few studies have examined the effect of different stages of economic development on the energy-GDP nexus, but to our knowledge no study has looked at countries in the MENA region in an effort to find out if the energy-GDP relationship depends on whether a country is a net oil exporter or net oil importer.

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