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The relationship between real GDP, CO_2 emissions, and energy use in the GCC countries: A time series approach

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Abstract: This paper examines the relationship among real GDP, CO_2 emissions, and energy use in the six Gulf Cooperation Council (GCC) countries. Using annual data for the years 1960–2013, stationarity, structural breaks, and cointegration tests have been conducted. The empirical evidence strongly supports the presence of unit roots. Cointegration tests reveal the existence of a clear long-run relationship only for Oman. Granger causality analysis shows that for three GCC countries (Kuwait, Oman, and Qatar) the predominance of the "growth hypothesis" emerges, since energy use drives the real GDP. Moreover, only for Saudi Arabia a clear long-run relation has not been discovered. Finally, the results of the variance decompositions and impulse response functions broadly confirm our previous empirical findings. Our results significantly reject the assumption that energy is neutral for growth. Notwithstanding, since the causality results are different for the six GCC countries, unified energy policies would not be the good recipe for the whole area.

Subjects: Energy efficiency; Energy Policy; Energy policy and economics

Keywords: economic growth; CO_2 emissions; energy use; GCC countries; time series

JEL classifications: B22; C32; N55; Q43

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PUBLIC INTEREST STATEMENT

The understanding of the direction of causality between energy and economic growth could have important policy implications. This research article explores the relationship among real GDP, carbon dioxide (CO_2) emissions, and energy use in the six Gulf Cooperation Council (GCC) countries. It was found that energy is generally expected to play a major role in achieving economic, social, and technological progress and to complement labour and capital in production for Kuwait, Oman, and Qatar. Hence, to ensure sustainable economic growth, all these countries should invest in clean energies (renewable energy resources: solar and wind) and adopt measures of energy efficiency. Nevertheless, since the causality results are different for the six GCC countries, unified energy policies would not be the good recipe for the whole area. Even though there may be political will to construct the common goals and objectives, different policy design for subgroups of member states ought to probably be considered.

1. Introduction

This paper investigates the relationship among economic growth, carbon dioxide (CO_2) emissions, and energy use for the Gulf Cooperation Council (GCC) countries. This is important because when a country's economy is heavily dependent on electric energy, environmental policies for energy conservation could adversely affect economic growth. Therefore, the understanding of the direction of causality between energy and economic growth could have important policy implications. The GCC was established in May 1981 and comprises Bahrain, Kuwait, Oman, Qatar, the Kingdom of Saudi Arabia, and the United Arab Emirates (Boussena, 1994).

The Climate Change Performance Index (CCPI) 2013 evaluates and compares the climate protection performance of 58 countries, that are, together, responsible for more than 90% of global energy-related CO_2 emissions.[1] In the 2013 CCPI, Iran and Saudi Arabia ranked, respectively, the penultimate and last on the list. As stated in the report, "the bottom three countries are Saudi Arabia, Iran, and Kazakhstan. All of them are highly dependent on their oil and gas exports. The distance in terms of scores to the better performing countries remains large and was constant over the previous years. The only gleam of hope is Saudi Arabia's announcement to present a strategy to invest in renewable energies" (Germanwatch, 2013). In addition, just 0.6% of the global population is living in the GCC countries, but the region is contributing 2.4% of the global greenhouse gas emissions (Raouf, 2008).

In light of the various determinants that influence the GCC energy strategy, understanding the time series behavior of GCC aggregate income, carbon dioxide emissions, and energy use is critical in the assessment of the impact of oil shocks and structural breaks on both energy and the repercussions for global economic activity (Barros, Gil-Alana, & Payne, 2011). In addition, the oil-exporting countries are among the most energy-intensive economies in the world because of the rising domestic demand and the development of energy-intensive industries. Furthermore, the high energy consumption implies the possibility of rapid erosion of their export capacity and the risk of turning into net importers. Consequently, the energy efficiency is a strategic issue for oil-exporting countries to manage environmental conflicts as well as economic ones (Damette & Seghir, 2013).

In literature, the nexus between environment and energy and growth has attracted attention of researchers in different countries for a long time. The empirical outcomes of these studies have been varied and sometimes conflicting. The results seem to be different on the direction of causality and long-term vs. short-term impact on energy policy (Magazzino, in press-b).

However, the majority of empirical studies concerning the relationship between economic growth and energy for Middle East countries concerns panel data studies; to our knowledge, this is the first paper that jointly analyzes the GCC case with regard to this topic. The paper contributes to the existing literature because the analysis focuses on GCC countries, and few studies have been devoted to this area before. In fact, relatively little attention has been paid to the environmental sustainability of this region despite there being significant sources of global energy supply and the potential impacts of this consumption on the environment (Salahuddin & Gow, 2014; Jammazi & Aloui, 2015; Salahuddin, Gow, & Ozturk, 2015). Therefore, this study is an attempt to fill this gap. In addition, we present an approach to cointegration based on the Gregory and Hansen (1996) test for cointegration with regime shifts, as well as the ARDL bounds test, which have never been applied to these countries.

Besides the Introduction, the remainder of this paper is organized as follows. Section 2 outlines the theoretical background and empirical evidence about this issue in Section 3. In Section 4, we briefly illustrate the data. Section 5 shows the empirical strategy, and Section 6 concludes, giving some policy implications.

2. Literature survey

The relationship between carbon dioxide emissions, energy consumption, and real output is a synthesis of the environmental Kuznets curve (EKC) and the energy consumption growth literature (Kuznets, 1955). The literature on the economic growth-energy consumption has been summarized in Magazzino (2014b), Omri (2014), and Ozturk (2010), while Magazzino (2014a) and Payne (2010) report an overview of the electricity demand–GDP nexus. Bo (2011) contains a survey on the EKC literature.

The directions of the causal relationship between energy consumption (or electricity consumption) and economic growth could be categorized into four types, each of which has important implications for energy policy (Squalli, 2007):

(1) "Neutrality hypothesis": no causality between energy consumption and GDP; it is supported by the absence of a causal relationship between energy consumption and real GDP;
(2) "Conservation hypothesis": unidirectional causality running from GDP to energy; it is supported if an increase in real GDP causes an increase in energy consumption;
(3) "Growth hypothesis": unidirectional causality running form energy to economic growth; increases in energy may contribute to growth process;
(4) "Feedback hypothesis": bidirectional causality between energy consumption and economic growth; it implies that energy consumption and economic growth are jointly determined and affected at the same time.

Further, with few exceptions, the issue of the relationship among GDP, energy and CO_2 emissions in the GCC countries has not been a subject of many researches. 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 (Shahateet, 2014). As explained in Al-Iriani (2006), this lack of attention may be explained by the view that GCC countries enjoy an access to abundant and cheap oil resources, making the study or adoption of energy conservation policies less pressing. Notwithstanding, this explanation is questionable on the ground of efficient use of resources, let alone environmental concerns. Maslyuk and Smyth (2009), studying the monthly crude oil production for 17 OPEC and non-OPEC countries over the period of January 1973–December 2007, found that for 11 of the countries a unit root was present in both regimes, while for the others a partial unit root was found to be present in either the first regime or second regime.

Empirical investigation of the relationship between these macroeconomic variables provides contrasting results. With regard to time series studies, Squalli and Wilson (2006) tested the electricity consumption–income growth hypothesis for the six member countries of the GCC. They found support for the "feedback hypothesis" in Bahrain, Qatar, and Saudi Arabia; results of Kuwait and Oman are in line with the "conservation hypothesis"; while the "neutrality hypothesis" emerges for the United Arab Emirates. Mehrara (2007b) studied the causality issue between energy consumption and economic growth for Iran, Kuwait, and Saudi Arabia. The results show a unidirectional long-run causality from economic growth to energy consumption for Iran and Kuwait, and unidirectional strong causality from energy consumption to economic growth for Saudi Arabia. Squalli (2007) investigated the relationship between electricity consumption and economic growth for OPEC members. Causality results suggest that a feedback mechanism holds in Iran, Qatar, and Saudi Arabia; for the United Arab Emirates, the "growth hypothesis" is confirmed; and the "conservation hypothesis" prevails in Kuwait. Narayan, Narayan, and Smyth (2008) investigated the unit root properties of crude oil production for 60 countries suggesting that for a world panel and smaller regional-based panels, crude oil and natural gas liquids (NGL) production are jointly stationary. Ozturk and Acaravci (2011) using an autoRegressive distributed lags (ARDL) bound cointegration approach investigated the relationship and the direction of causality between electricity consumption and economic growth for 11 Middle East and North Africa countries (MENA). The overall results indicate that there is no relationship between the electricity consumption and the economic growth in most of the

Table 1. Summary of existing literature on energy use-emissions-GDP nexus for Middle-East countries

Author(s)	Country	Study period	Empirical strategy
Al-Iriani (2006)	6 GCC countries	1971–2002	Panel data
Ramanathan (2006)	18 MENA countries	1997–1999	Data envelopment analysis
Squalli and Wilson (2006)	6 GCC countries	1980–2003	Time series
Mehrara (2007a)	11 oil exporting countries	1971–2002	Panel data
Mehrara (2007b)	Iran, Kuwait, and Saudi Arabia	1971–2002	Time series
Squalli (2007)	OPEC countries	1980–2003	Time series
Lee and Chang (2008)	16 Asian countries	1971–2002	Panel data
Narayan et al. (2008)	60 countries	1971–2003	Panel data
Narayan and Smyth (2009)	6 Middle Eastern countries	1974–2002	Panel data
Ozturk, Aslan, and Kalyoncu (2010)	51 low and middle income countries	1971–2005	Panel data
Al-mulali (2011)	16 MENA countries	1980–2008	Panel data
Barros et al. (2011)	13 OPEC countries	January 1973–October 2008	Time series
Mohamad and Said (2011)	54 OIC countries	2003–2007	Data envelopment analysis
Ozturk and Acaravci (2011)	11 MENA countries	1990–2006	Time series
Arouri and Rault (2012)	12 MENA countries	1981–2005	Panel data
Arouri, Ben Youssef, M'henni, and Rault (2012)	12 MENA countries	1981–2005	Panel data
Farhani and Ben Rejeb (2012)	15 MENA countries	1973–2008	Panel data
Haghnejad and Dehnavi (2012)	8 OPEC countries	1971–2008	Time series
Alsahlawi (2013)	6 GCC countries	1980–2009	Data envelopment analysis
Altaee and Adam (2013)	Bahrain	1975–2010	Time series
Damette and Seghir (2013)	12 oil exporting countries	1990–2010	Panel data
Farhani, Shahbaz, and Arouri (2013)	11 MENA countries	1980–2009	Panel data
Hamdi and Sbia (2013)	Bahrain	1960–2010	Time series
Omri (2013)	14MENA countries	1990–2011	Panel data
Papadopoulou, Afshari, Anastasopoulos, and Psarras (2013)	6 GCC countries	–	Demand Side Management analysis
Hamdi et al. (2014)	Bahrain	1980–2010	Time series
Salahuddin and Gow (2014)	6 GCC countries	1980–2012	Panel data
Sbia et al. (2014)	United Arab Emirates	1975–2011	Time series
Shahateet (2014)	17 Arab countries	1980–2011	Time series
Alshehry and Belloumi (2015)	Saudi Arabia	1971–2010	Time series
Jammazi and Aloui (2015)	6 GCC countries	1980–2013	Wavelet window cross-correlation
Magazzino (in press-a)	10 Middle East countries	1971–2006	Panel data
Magazzino (2015)	Israel	1971–2006	Time series
Omri et al. (2015)	12 MENA countries	1990–2011	Panel data
Saidi and Hammami (2015)	58 countries	1990–2012	Panel data
Salahuddin et al. (2015)	6 GCC countries	1980–2012	Panel data

Source: Our elaborations.

MENA countries. In the case of Bahrain, Hamdi and Sbia (2013) examined the direction of causality between electricity consumption and economic growth and found a feedback effect between both variables. Altaee and Adam (2013) explored the nexus between electricity consumption and economic growth in Bahrain. The results show a unidirectional long-run causality from economic growth to electricity consumption. Thus, these results support the "conservation hypothesis". Hamdi, Sbia, and Shahbaz (2014) explored the relationship between electricity consumption, foreign direct investment, capital and economic growth in the case of Bahrain using a Cobb–Douglas production function. Empirical results underlined a feedback effect between electricity consumption and economic growth, as well as between foreign direct investment (FDI) and electricity consumption. Sbia, Shahbaz, and Hamdi (2014) studied the relationship between foreign direct investment, clean energy, trade openness, carbon emissions, and economic growth in the case of the United Arab Emirates. Foreign direct investment, trade openness, and carbon emissions decline energy demand, while economic growth and clean energy have a positive impact on energy consumption. Salahuddin and Gow (2014) examined the empirical relationship among economic growth, energy consumption, and carbon dioxide emissions, in GCC countries. The results indicate a positive and significant association between energy consumption and CO_2 emissions and between economic growth and energy consumption both in the short- and the long-run. No significant relationship is found between economic growth and CO_2 emissions. Alshehry and Belloumi (2015) investigated the dynamic causal relationships among energy consumption, energy price, and economic activity in Saudi Arabia, using a Johansen multivariate cointegration approach. The results indicate that there exists at least a long-run relationship between energy consumption, energy price, carbon dioxide emissions, and economic growth. Jammazi and Aloui (2015) investigated the crosslinkages among CO_2 emission, economic growth, and energy consumption for GCC countries with the approach of wavelet window cross-correlation. The results pointed out the existence of bilateral causal effects between energy consumption and economic growth, while only a unidirectional relationship was found from energy to emissions. Omri, Daly, Rault, and Chaibi (2015) examined the relationship among financial development, CO_2 emissions, trade and economic growth using simultaneous equation panel data models for a panel of 12 MENA countries. The results indicate that there is evidence of bidirectional causality between CO_2 emissions and economic growth. Economic growth and trade openness are interrelated i.e. bidirectional causality. Feedback hypothesis is validated between trade openness and financial development. Neutrality hypothesis is identified between CO_2 emissions and financial development. Salahuddin et al. (2015) analyzed the relationship among carbon dioxide emissions, economic growth, electricity consumption, and financial development in the GCC area. No significant short-run relationship was observed. The findings imply that electricity consumption and economic growth stimulate CO2 emissions in GCC countries while financial development reduces it (Table 1).

Hertog and Luciani (2009) concluded that many of the Gulf regimes' current sustainability-oriented energy policies can be pursued on a project basis, building on efficient technocratic enclaves under the direct patronage of rulers. These are more likely to be successful than broader regulatory strategies aimed at changing consumer and business behavior in general.

3. Methodology

The first step of our empirical strategy concerns stationarity and unit root tests. According to Engle and Granger (1987), a linear combination of two non-stationary series can be stationary, and if such a stationarity exists, the series are considered to be cointegrated. This requires, however, that the series have the same order of integration. Therefore, the Augmented Dickey and Fuller (ADF, 1979), the Elliott, Rothenberg, and Stock (ERS, 1996), the Phillips and Perron (PP, 1988), and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) tests were performed to test whether the data are difference stationary or trend stationary, as well as to determine the number of unit roots at their levels. Moreover, we also checked if any of the variables have structural breaks. To this extent, the Zivot and Andrews (ZA, 1992) and the Clemente, Montañés, and Reyes (CMR, 1998) tests were performed.

Once we found that the variables are non-stationary at their levels and are in the same order of the integration, we can apply the Johansen and Juselius (1990) cointegration test.

Three tests statistics are suggested to determine the number of cointegration vectors: the first is the Johansen's "trace" statistic method, the second is the "maximum eigenvalue" statistic method, and the last one chooses r to minimize an information criterion.

However, due to the small sample size (47 yearly observations) used in the present study, it is possible that the Johansen test statistics may be biased. Therefore, we follow the approach by Reinsel and Ahn (1992), who suggest multiplying the Johansen trace statistics with the scale factor *N/(N-pk)*, where *N* is the number of observation, *k* is the number of variables, and *p* is the lag parameter in the estimated VAR system. Such a procedure corrects for small sample bias and allows more appropriate statistical interferences to be made with small samples. If the cointegrating relationship is found then in order to account for non-stationary variables the VECM model has to be estimated.

Cointegration analysis considered also the Gregory and Hansen (1996) test for cointegration with regime shifts. The null hypothesis (H_0) is no cointegration, against the alternative (H_1) of cointegration with a single shift at an unknown point in time.

The ARDL bounds testing approach of cointegration is developed by Pesaran and Shin (1999) and Pesaran, Shin, and Smith (2001). This approach has several advantages over the traditional cointegration approaches. The main constraint in the application of the conventional cointegration techniques is that they require all the variables included in the model to be non-stationary at levels but should be integrated of the same order. The ARDL approach to cointegration method surmounts this problem. Apart from that, the ARDL model also has advantages in selecting sufficient numbers of lags to capture the data generating process in a general-to-specific modeling framework.

Moreover, two causality tests are conducted. Firstly, Granger non-causality test is carried out following the Toda and Yamamoto (1995, TY) long-run causality test. Furthermore, a "standard" Granger causality analysis has been developed. A time series X_t is said to Granger-cause another time series Y_t if the prediction error of current *Y* declines by using past values of *X* in addition to past values of *Y* (Granger, 1969).

Finally, we discuss the forecast error variance decomposition (FEVD), determining how much the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables.

4. Data

Annual data were utilized in the analysis, although the sampling period may differ between countries depending on the availability of data. CO_2 emissions and energy use series were obtained by World Development Indicators (WDI) database[2], while real per capita GDP is derived from Total Economy Database (TED)[3].

For real GDP the data started in 1960 and ended in 2013, for energy use the data range is 1971–2007, while CO_2 emissions series covered the period 1960–2006. Moreover, for Kuwait the years 1992–1994 are missed in emissions and energy use series. The variables employed in the analysis were the real GDP (*RPCGDP*), CO_2 emissions (CO_2), and energy use (*PCEU*). All the variables are expressed in per capita terms and converted in logarithmic series (Table 2).

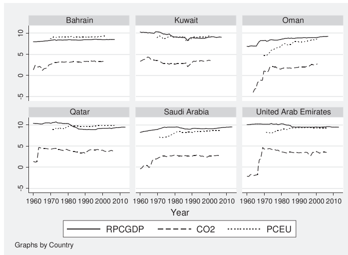
We computed the partial correlation between real GDP and energy use to impart a first impression on the relationship between these variables in the GCC countries. The correlation ranges from 0.91 (Oman) to −0.29 (the United Arab Emirates) and, hence, the impression we get is that *RPCGDP* is generally positive correlated with *PCEU*.

Table 2. Variable definitions

Abbreviation	Description	Source
RPCGDP	GDP per capita in 1990 US$ (converted at Geary Khamis PPPs)	TED
CO_2	CO_2 emissions (metric tons per capita)	WDI
PCEU	Per capita energy use, kg of oil equivalent	WDI

Figure 1. Real GDP, CO_2 emissions and energy use in the GCC (1960–2013, log-scale).

Sources: TED and WDI data.



Sources: TED and WDI data.

A graphical description of our data is shown in the following Figure 1.

5. Empirical investigation

In Table 3, an exploratory data analysis is given. Interestingly, all the variables seem to have a normal distribution, since for each variable the mean value is near to the 10-Trim one. Moreover, each standard deviation is similar to the relative pseudo-standard deviation.

Standard unit root and stationarity tests were performed for each series, first on levels and then on first differences. The ADF, ERS, PP, and KPSS tests were performed. As shown in Table 4, in general, these tests failed to reject the null hypothesis of a unit root for all variables at 5% significance levels. In fact, only for CO_2 emissions in Oman and Qatar the tests results are controversial. However, we ought to remember that the KPSS semi-parametric unit root test uses a null hypothesis of

Table 3. Exploratory data analysis

Variable	Mean	SD	Minimum	Maximum	IQR	10-Trim	Pseudo SD
RPCGDP	9.1202	0.7345	6.8278	10.6670	0.9819	9.124	0.7278
CO_2	2.6927	1.4544	−4.0408	4.6610	1.2970	2.927	0.9613
PCEU	8.6827	0.9685	4.6836	9.9411	0.9629	8.826	0.7138
Country		**Variable**	**Mean**	**Median**	**SD**	**Skewness**	**Kurtosis**
Bahrain		RPCGDP	8.3440	8.3897	0.1528	−1.3098	3.6459
		CO_2	2.8770	3.1616	0.6117	−1.4308	3.7237
		PCEU	9.0760	9.0838	0.1277	−0.9519	5.9584
Kuwait		RPCGDP	9.3604	9.0838	0.5723	0.4008	1.7684
		CO_2	3.2510	3.3593	0.4682	0.0266	2.8751
		PCEU	9.0308	9.1018	0.2557	−2.1088	7.3716
Oman		RPCGDP	8.4630	8.7814	0.6905	−1.2681	3.5162
		CO_2	1.1980	1.7801	1.6507	−1.8942	5.5121
		PCEU	7.2450	7.5106	1.1641	−0.9059	2.7564
Qatar		RPCGDP	9.6562	9.4420	0.6303	0.2132	1.3726
		CO_2	3.8126	3.9929	0.7482	−2.4311	8.9253
		PCEU	9.6100	9.7112	0.3082	−1.2186	3.0975
Saudi Arabia		RPCGDP	9.1110	9.1143	0.3201	−0.9705	3.5695
		CO_2	2.1917	2.5958	0.9295	−1.7469	4.5617
		PCEU	8.1565	8.3501	0.5470	−1.1200	2.8142
United Arab Emirates		RPCGDP	9.7863	9.5753	0.3210	0.1660	1.1723
		CO_2	2.7341	3.4526	2.0366	−1.7240	4.3569
		PCEU	9.0061	9.2500	0.4246	−1.2158	3.0289

Notes: SD: Standard Deviation; IQR: Inter-Quartile Range; PSD: Pseudo Standard Deviation.
Sources: Our calculations on WDI and TED data.

Table 4. Results for unit roots and stationarity tests

Test statistics				
	ADF	**ERS**	**PP**	**KPSS**
A: Level				
Bahrain				
RPCGDP	−2.160 (−3.497)	−1.277 (−3.166)	−2.137 (−3.497)	0.430*** (0.146)
CO_2	−2.770 (−3.516)	−1.384 (−3.209)	−2.824 (−3.516)	0.376*** (0.146)
PCEU	−1.066 (−3.568)	−1.857 (−3.156)	−3.780** (−3.556)	0.150** (0.146)
Kuwait				
RPCGDP	−1.248 (−3.497)	−1.608 (−3.166)	−1.381 (−3.497)	0.493*** (0.146)
CO_2	−0.302 (−2.952)	–	−0.371 (−2.952)	–
PCEU	−2.791* (−2.986)	–	−1.882 (−2.980)	–
Oman				
RPCGDP	−2.100 (−3.499)	−1.572 (−3.129)	−2.056 (−3.497)	0.330*** (0.146)
CO_2	−3.592** (−3.544)	−0.798 (−3.239)	−3.580** (−3.532)	0.370*** (0.146)
PCEU	−2.875 (−3.560)	−1.572 (−3.293)	−1.729 (−3.556)	0.390*** (0.146)
Qatar				
RPCGDP	−1.154 (−2.928)	−0.659 (−2.245)	−1.184 (−2.928)	2.010*** (0.463)
CO_2	−4.010*** (−2.941)	−1.365 (−2.285)	−4.011*** (−2.941)	0.153 (0.463)
PCEU	−2.142 (−3.564)	−2.314 (−3.230)	−2.735 (−3.556)	0.197** (0.146)
Saudi Arabia				
RPCGDP	−2.537 (−2.930)	−0.346 (−2.245)	−2.750* (−2.928)	1.000*** (0.463)
CO_2	−2.759* (−2.947)	−0.352 (−2.285)	−3.309** (−2.941)	0.979*** (0.463)
PCEU	−2.510 (−3.560)	−1.978 (−3.293)	−1.389 (−3.556)	0.337*** (0.146)
United Arab Emirates				
RPCGDP	−0.647 (−2.928)	−0.620 (−2.245)	−0.705 (−2.928)	2.310*** (0.463)
CO_2	−3.048** (−2.947)	−1.272 (−2.259)	−2.461 (−2.941)	0.632** (0.463)
PCEU	−1.175 (−3.556)	−1.880 (−3.293)	−1.103 (−3.556)	0.435*** (0.146)
B: First differences				
Bahrain				
RPCGDP	−7.299*** (−2.928)	−4.833*** (−2.250)	−7.299*** (−2.928)	0.387* (0.463)
CO_2	−3.278** (−2.952)	−1.135 (−2.292)	−8.941*** (−2.944)	0.202 (0.463)
PCEU	−4.234*** (−2.978)	−2.703*** (−2.336)	−8.227*** (−2.972)	0.148 (0.463)
Kuwait				
RPCGDP	−6.307*** (−2.928)	−5.221*** (−2.250)	−6.319*** (−2.928)	0.172 (0.463)
CO_2	−4.412*** (−2.958)	–	−4.375*** (−2.958)	–
PCEU	−5.367*** (−2.986)	–	−5.368*** (−2.986)	–
Oman				
RPCGDP	−5.027*** (−2.929)	−4.724*** (−2.250)	−4.308*** (−2.928)	0.288 (0.463)
CO_2	−6.725*** (−2.955)	−2.501** (−2.321)	−6.723*** (−2.955)	0.592** (0.463)
PCEU	−3.591*** (−2.972)	−3.680*** (−2.374)	−3.661*** (−2.972)	0.430* (0.463)
Qatar				
RPCGDP	−4.557*** (−2.928)	−2.922*** (−2.250)	−4.484*** (−2.928)	0.293 (0.463)
CO_2	−6.580*** (−2.944)	−5.387*** (−2.292)	−6.580*** (−2.944)	0.201 (0.463)
PCEU	−9.640*** (−2.972)	−4.430*** (−2.336)	−9.175*** (−2.972)	0.132 (0.463)

(Continued)

Table 4. (*Continued*)

Test statistics	ADF	ERS	PP	KPSS
Saudi Arabia				
RPCGDP	−3.426** (−2.928)	−2.461** (−2.250)	−3.404** (−2.928)	0.379* (0.463)
CO_2	−5.636*** (−2.947)	−4.582*** (−2.292)	−5.508*** (−2.944)	0.432* (0.463)
PCEU	−4.417*** (−2.972)	−1.548 (−2.374)	−4.441*** (−2.972)	0.236 (0.463)
United Arab Emirates				
RPCGDP	−6.278*** (−2.928)	−4.299*** (−2.250)	−6.277*** (−2.928)	0.149 (0.463)
CO_2	2.847** (−2.947)	−2.732*** (−2.292)	−6.705*** (−2.944)	0.362* (0.463)
PCEU	−6.471*** (−2.972)	−2.227* (−2.374)	−6.465*** (−2.972)	0.285 (0.463)

Notes: The tests are performed on the log-levels of the variables. ADF, DF-GLS, PP, and KPSS refers respectively to the Augmented Dickey-Fuller test, the Elliot, Rothenberg, and Stock GLS test, the Phillips-Perron test, and the Kwiatkowski, Phillips, Schmidt, and Shin test. When it is required, the lag length is chosen according to the Schwartz Bayesian Information Criterion (SBIC). 5% Critical Values are given in parentheses.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

stationarity against the alternative hypothesis of a unit root. The results of the KPSS test strongly reject the *I(0)* null at 95% confidence level, with the only exception of CO_2 variable in the case of Qatar. Thus, these univariate unit root and stationarity tests yield results that are consistent with the notion that all the variables are non-stationary in level but stationary in first difference, or *I(1)*.

However, these results might be misleading because of shocks due to policy changes, currency crisis, or rapid fluctuation of world prices for primary commodities. Thus, the ZA and CMR tests have been performed, to consider potential structural breaks. The results of ZA and CMR tests are reported in Table 5; they reveal that significant structural breaks are detected especially for *PCEU*. The tests, as largely expected, place the breaks in the 70s, during the two oil crises, and in the mid-1980s, following the Iran–Iraq war. Thus, the evidence strongly supports the presence of unit roots. Given the fact that for Kuwait the data for 1992–1994 years are not available, the two tests are missed.

Toda and Yamamoto (1995) have proposed the Modified Wald (MWald) for testing Granger non-causality that allows causal inference to be conducted in the level VARs that may contain integrated and (non-)cointegrated processes and require the determination of the true lag length of the model. This procedure imposes (non-)linear restrictions on the parameters of VAR models without having to pretest for unit root and cointegrating rank. Once the optimum lag length (k) has been found and the congruency of the VAR duly examined through the standard diagnostics test, the causality test was formulated as a zero restriction on the coefficient of the lags of the other variables by χ^2-test statistics. It is evident from Table 6 that the null hypothesis of non-Granger causality between real per capita GDP and energy use is easily rejected at the 5% significance level for all the countries except the United Arab Emirates. In fact, for three countries (Kuwait, Oman, and Qatar) a unidirectional causal link emerges, running from energy use to the aggregate income. These results are in line with the "growth hypothesis". Furthermore, the opposite direction of causality is observed for Bahrain, where "conservation hypothesis" holds. Finally, for Saudi Arabia a feedback mechanism emerges (*RPCGDP*↔*PCEU*).

Therefore, a strong causality nexus has been discovered in GCC countries. These causality results are in line with empirical findings in Squalli (2007), and Squalli and Wilson (2006) (Table 7).

The Johansen and Juselius (1990) procedure employs two likelihood ratio (LR) test statistics to determine the number of cointegrating vectors: the trace test and the maximal eigenvalue (λ-max) cogent • economics & finance

Table 5. Results for unit root with structural breaks tests

Test statistics				
	ZA (A)	**ZA (B)**	**CMR (A)**	**CMR (B)**
A: Level				
Bahrain				
RPCGDP	−3.282 [1968]	−4.291* [1973]	−2.993 [1980]	−3.424* [1975]
CO_2	−6.072*** [1970]	−3.558 [1978]	−6.954*** [1968]	−1.616 [1971]
PCEU	−3.636 [1986]	−4.616** [2001]	−3.400 [2000]	−4.567*** [2002]
Kuwait				
RPCGDP	−3.599 [1980]	−3.235 [1992]	−3.914* [1978]	−4.037** [1977]
CO_2	–	–	–	–
PCEU	–	–	–	–
Oman				
RPCGDP	−2.434** [1974]	−6.009*** [1970]	−3.489 [1965]	−0.419*** [1971]
CO_2	−6.334*** [1971]	−5.292*** [1972]	−4.817*** [1969]	0.502 [1972]
PCEU	−3.417 [1982]	−5.158*** [1984]	−3.636 [1988]	−2.419 [1984]
Qatar				
RPCGDP	−4.434 [1981]	−2.627 [1991]	−5.186*** [1979]	−3.252* [1987]
CO_2	−3.990 [1980]	−3.759 [1992]	−4.017* [1978]	−2.458 [1981]
PCEU	−6.113*** [1979]	−4.567** [1983]	−6.335*** [1977]	−1.223 [1976]
Saudi Arabia				
RPCGDP	−4.107 [1983]	−2.495 [2003]	−2.879 [2001]	−2.949 [1975]
CO_2	−3.856 [1969]	−5.659*** [1974]	−8.632*** [1965]	−4.533*** [1968]
PCEU	−5.792*** [1978]	−4.546** [1981]	−4.549** [1976]	−3.743** [1982]
United Arab Emirates				
RPCGDP	−4.871** [1985]	−2.713 [1994]	−5.956*** [1984]	−6.340*** [1983]
CO_2	−2.816 [1986]	−7.049*** [1970]	−3.505 [1965]	−1.332 [1966]
PCEU	−4.094 [1977]	−5.187*** [1986]	−6.001*** [1975]	−2.833 [1981]
B: First differences				
Bahrain				
RPCGDP	−8.927*** [1975]	−7.954*** [1986]	−10.438*** [1974]	−2.746 [1973]
CO_2	−2.611 [1978]	−3.908 [1970]	−1.582 [1965]	−4.992*** [1968]
PCEU	−5.135** [1986]	−4.493** [1992]	−10.081*** [1976]	−0.909 [1975]
Kuwait				
RPCGDP	−7.697*** [1992]	−6.551*** [1981]	−8.370*** [1990]	−4.685*** [1989]
CO_2	–	–	–	–
PCEU	–	–	–	–
Oman				
RPCGDP	−5.727*** [1973]	−5.319*** [1991]	−6.880*** [1972]	−1.632 [1971]
CO_2	−9.455*** [1977]	−9.188*** [1981]	−3.783 [1975]	−0.980 [1969]
PCEU	−4.644* [1985]	−4.521** [1987]	−5.156*** [1985]	−1.780 [1981]
Qatar				
RPCGDP	−6.082*** [1974]	−5.660*** [1983]	−5.376*** [1985]	−5.258*** [1984]
CO_2	−7.412*** [1968]	−8.635*** [1968]	−16.212*** [1965]	−13.877*** [1963]
PCEU	−4.826** [1983]	−4.194* [1989]	−11.231*** [1979]	−4.763*** [1978]

(Continued)

Table 5. (*Continued*)

Test statistics				
	ZA (A)	ZA (B)	CMR (A)	CMR (B)
Saudi Arabia				
RPCGDP	−3.700 [1975]	−3.464 [1984]	−3.157 [1972]	−2.686 [1976]
CO_2	−6.936*** [1974]	−6.401*** [1985]	−9.103*** [1966]	−2.520 [1965]
PCEU	−6.767*** [1982]	−5.167*** [1988]	−6.527*** [1980]	−3.020* [1982]
United Arab Emirates				
RPCGDP	−7.079*** [1981]	−6.851 [1986]	−8.134*** [1985]	−6.430*** [1984]
CO_2	−4.297 [1971]	−3.382 [1979]	−9.426*** [1968]	−5.901*** [1967]
PCEU	−6.196*** [2002]	−6.333*** [2001]	−2.871 [1976]	−1.101 [1975]

Notes: ZA(A): model allowing for break in intercept; ZA(B): model allowing for break in trend. CMR(A): innovative outlier unit root tests (single structural break); CMR(B): additive outlier unit root tests (single structural break).

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

Table 6. Toda and Yamamoto causality results

Dep. Variable	RPCGDP	CO_2	PCEU
Bahrain (k = 1, d = 1)			
RPCGDP	–	2.342 (0.310)	2.307 (0.315)
CO_2	1.426 (0.490)	–	0.548 (0.760)
PCEU	16.354*** (0.000)	2.303 (0.316)	–
Kuwait (k = 2, d = 1)			
RPCGDP	–	7.059* (0.070)	14.312*** (0.003)
CO_2	12.326*** (0.006)	–	31.744*** (0.000)
PCEU	1.154 (0.764)	1.873 (0.599)	–
Oman (k = 2, d = 1)			
RPCGDP	–	23.477*** (0.000)	15.864*** (0.001)
CO_2	16.435*** (0.001)	–	2.635 (0.451)
PCEU	1.181 (0.757)	0.459 (0.928)	–
Qatar (k = 1, d = 1)			
RPCGDP	–	4.872* (0.088)	11.830*** (0.003)
CO_2	5.684* (0.058)	–	6.805** (0.033)
PCEU	0.043 (0.979)	0.540 (0.763)	–
Saudi Arabia (k = 2, d = 1)			
RPCGDP	–	3.415 (0.332)	9.552** (0.023)
CO_2	0.596 (0.897)	–	1.147 (0.766)
PCEU	8.304** (0.040)	3.813 (0.282)	–
United Arab Emirates (k = 1, d = 1)			
RPCGDP	–	0.286 (0.867)	3.418 (0.181)
CO_2	3.964 (0.138)	–	15.783*** (0.000)
PCEU	0.742 (0.690)	0.377 (0.828)	–

Notes: The sum of the lagged coefficients represents the summation of the lags excluding the second or third lag as discussed in Rambaldi and Doran (1996), Rambaldi (1997), Zapata and Rambaldi (1997), Caporale and Pittis (1999), and Wolde-Rufael (2005).

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

Table 7. Summary of causality tests results

Hypothesis	Causality flow	Countries
Feedback	RPCGDP↔PCEU	1: Saudi Arabia
Conservation	RPCGDP→PCEU	1: Bahrain
Growth	PCEU→RPCGDP	3: Kuwait, Oman, Qatar
Neutrality	–	1: United Arab Emirates

test. We relied on the correction factor suggested by Reinsel and Ahn (1992) to the estimated maximum eigenvalue and trace statistics. The correction factor suggested is the multiplication of the test statistic by $(T-pk)/T$, where T is the sample size, p is the number of variables, and k is the lag length for the VAR model. The lag-order selection has been chosen according to the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC). Results of the Johansen cointegration procedure are presented in Table 8.

Since we have a three-year gap in the series of Kuwait due to the effects of the First Gulf War, we report the results only for the remaining five countries. As clearly emerges from cointegration results, the tests reach mixed conclusions. The null hypothesis of no cointegrating vector ($r = 0$) was rejected at 5% significance level only for Saudi Arabia. On the other hand, both the tests failed to reject the null hypothesis of non-cointegration in the case of Bahrain, Oman, and Qatar. While for the trace test, the null hypothesis (H_0: $r = 0$) is rejected against the alternative (H_a: $r \geq 1$) for the United Arab Emirates.

However, the results of the Johansen procedure are sensitive to structural breaks in the long-run cointegrating relationship. To allow for this possibility, we applied the Gregory and Hansen (1996) cointegration test with breaks. Briefly, under this procedure, a dummy variable is included to account for a shift in the cointegrating regression. The minimum ADF statistic endogenously determines the breakpoint and is compared to critical values supplied by Gregory and Hansen (1996). The procedure offers four different models corresponding to the four different assumptions concerning the nature of the shift in the cointegrating vector. Table 9 clearly shows the existence of cointegration with a break for the Oman in constant and trend. The test statistics indicate that the break is likely to be in 1971, confirming the results of structural breaks tests. For Qatar, the test suggests the presence of a long-run relation with a break in constant and slope, occurred in 1973. While for the United Arab Emirates cointegration emerges, with a break in constant and slope, dated 1970.

The bounds *F*-test for cointegration yields evidence of a long-run relationship among real income, emissions, and energy use at 1% significance level for Oman, while in the case of Qatar and United Arab Emirates we reject the null of no cointegration only at 10%, in line with results by Charfeddine and Khediri (2016). For the remaining three countries (Bahrain, Kuwait, and Saudi Arabia) it emerges that a long-run relation among these three variables do not exist (Table 10). These results broadly confirm those shown in Table 9, reaffirming the relevance of structural breaks in our sample.

However, it is well established that the results of FEVD based on Choleski's decomposition are generally sensitive to the ordering of the variables and the lag length (Lütkepohl, 1991). The results of the conventional FEVD are predetermined by the manner in which the system variables are ordered. To overcome this shortcoming, the generalized variance decomposition (GVDCs) provided by Lee, Pesaran, and Pierse (1992) and Lee and Pesaran (1993) was applied here. Similarly, we conducted the generalized impulse response functions (GIRFs), based on Pesaran and Shin (1998).

Results of the GVDC from 1 to 10 steps for the system are given in Table 11. The major findings may be summarized as follows. First, it can be seen that the shocks in the energy use contribute more in explaining the forecast error variance in real GDP for Kuwait, Oman, Qatar, and Saudi Arabia.

Table 8. Johansen's multivariate cointegration tests

		λ_{max}	Trace	IC		
Null	Alternative	Statistic	Statistic	SBIC	HQIC	AIC
Bahrain						
$r = 0$	$r = 1$	33.3863	43.2581	−6.5555	−6.8217	−6.9595
$r \leq 1$	$r = 2$	9.8465*	9.8718*	−7.0189*	−7.4330	−7.6474
$r \leq 2$	$r = 3$	0.0253	0.0253	−6.9973	−7.5002*	−7.7605*
Oman						
$r = 0$	$r = 1$	33.4260	54.6434	−3.4073	−3.8510	−4.0806
$r \leq 1$	$r = 2$	19.1250	21.2174	−3.8718	−4.4634	−4.7696
$r \leq 2$	$r = 3$	2.0924*	2.0924*	−4.1231*	−4.8035*	−5.1557*
Qatar						
$r = 0$	$r = 1$	26.0821	37.9413	−3.2405	−3.4151	−3.5072
$r \leq 1$	$r = 2$	10.5493*	11.8591*	−3.4778*	−3.7979	−3.9667
$r \leq 2$	$r = 3$	1.3099	1.3099	−3.4745	−3.8819*	−4.0966*
Saudi Arabia						
$r = 0$	$r = 1$	12.0926*	28.0200*	−5.9409*	−6.2959	−6.4796
$r \leq 1$	$r = 2$	10.0553	15.9275	−5.7780	−6.2809	−6.5412
$r \leq 2$	$r = 3$	5.8722	5.8722	−5.7626	−6.3543*	−6.6605*
United Arab Emirates						
$r = 0$	$r = 1$	19.1441*	33.9293	−3.2148	−3.5698	−3.7535
$r \leq 1$	$r = 2$	8.6550	14.7852*	−3.2593*	−3.7622	−4.0225
$r \leq 2$	$r = 3$	6.1302	6.1302	−3.2027	−3.7944*	−4.1006*

Notes: The adjusted statistics are the standard Johansen statistics and the statistics adjusted for small sample correction factor according to Reinsel and Ahn (1992) respectively. Critical values for both the trace and maximum eigenvalue tests are tabulated in Osterwald-Lenum (1992).

Table 9. Gregory and Hansen cointegration tests

Country	Constant	Constant and trend	Constant and slope	Constant, slope and trend
Bahrain	−4.40 (1982)	−4.40 (1974)	−4.94 (1985)	−5.41 (1978)
Oman	−4.69* (1971)	−5.08* (1971)	−4.91 (1971)	−5.49 (1971)
Qatar	−3.38 (1972)	−3.43 (1988)	−5.56** (1973)	−5.51 (1973)
Saudi Arabia	−4.53 (1972)	−4.76 (1972)	−4.22 (1972)	−5.09 (1972)
United Arab Emir-ates	−5.28** (1973)	−5.13* (1973)	−5.69** (1970)	−5.53 (1970)

Notes: 5% Critical values: −4.92, −5.29, −5.50, −5.96 respectively.
$^*p < 0.10$.
$^{**}p < 0.05$.

For example, innovations in the energy use explained 73% of Kuwait's and 42% of Qatar's aggregate income variance at the 10-year horizon. Meanwhile, the real GDP has a greater impact on the energy use only in Bahrain, with the same horizon. In fact, for the remaining 5 GCC countries, the forecast error variance in energy use due to a shock in real GDP ranges from 1% (for Oman) to 14% (for Saudi Arabia). Thus, these results strengthen the causality chain presented earlier, giving further support to the body of literature that suggests that energy use has a causal relationship with real GDP.

Table 10. ARDL bounds test estimation results

Country	Model for estimation	Lag length	*F*-statistics	Significance level	Critical bound *F*-statistics *I*(0)	Critical bound *F*-statistics *I*(1)
Bahrain	$F_{RPCGDP}^{CO2,PCEU}$	1	1.882	1	5.15	6.36
				5	3.79	4.85
				10	3.17	4.14
Kuwait	$F_{RPCGDP}^{CO2,PCEU}$	2	1.725	1	5.15	6.36
				5	3.79	4.85
				10	3.17	4.14
Oman	$F_{RPCGDP}^{CO2,PCEU}$	2	11.741***	1	5.15	6.36
				5	3.79	4.85
				10	3.17	4.14
Qatar	$F_{RPCGDP}^{CO2,PCEU}$	1	4.821*	1	5.15	6.36
				5	3.79	4.85
				10	3.17	4.14
Saudi Arabia	$F_{RPCGDP}^{CO2,PCEU}$	2	2.903	1	5.15	6.36
				5	3.79	4.85
				10	3.17	4.14
United Arab Emirates	$F_{RPCGDP}^{CO2,PCEU}$	1	4.359*	1	5.15	6.36
				5	3.79	4.85
				10	3.17	4.14

Notes: Asymptotic critical value bounds are obtained from table *F*-statistic in Pesaran et al. (2001).
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

In contrast, CO_2 emissions emerged as the most exogenous variable for the same horizon. For example, 87% of the variation in emissions is explained by its own shock in Saudi Arabia after the 10-year horizon.

Examining the GIRFs, for Bahrain a shock to *RPCGDP* affects CO_2 and *PCEU* for few periods, but dies out very quickly. A similar pattern is found studying how emissions respond to a shock in the energy use. In contrast, for Kuwait a shock in the energy use affects more persistently the real GDP and CO_2 emissions. In general, the GIRFs analyses suggest that the life of the exogenous shocks is different among the GCC countries, reinforcing our previous findings.

6. Concluding remarks and policy implications

This study has used several time series econometric techniques in order to explore the relationship between real GDP, CO_2 emissions, and energy use in the six GCC countries, for 1960–2013 years.

Unit roots and stationarity tests failed to reject the hypothesis of a unit root for all variables at 5% significance levels. The structural breaks tests place the breaks in the 70s, during the two oil crises, and in the mid-1980s, following the Iran–Iraq war. Thus, the evidence strongly supports the presence of unit roots. Causality tests show for three countries (Kuwait, Oman, and Qatar) a unidirectional causal link, running from energy use to the aggregate income, giving empirical support to the "energy-led growth hypothesis." Furthermore, the opposite direction of causality is observed for Bahrain, where "conservation hypothesis" holds. Finally, for Saudi Arabia a feedback mechanism emerges. The "neutrality hypothesis" holds only in the case of the United Arab Emirates. In

Table 11. Variance decomposition

Percentage of variations in	Horizon	Due to innovation in		
		ΔRPCGDP	**ΔCO_2**	**ΔPCEU**
Bahrain				
Relative variance in: ΔRPCGDP				
	1	**1.0000**	0.0000	0.0000
	3	**0.9498**	0.0253	0.0249
	6	**0.9219**	0.0345	0.0436
	10	**0.9194**	0.0357	0.0449
Relative variance in: ΔCO_2				
	1	0.0068	**0.9932**	0.0000
	3	0.0079	**0.9145**	0.0776
	6	0.0996	**0.7891**	0.1113
	10	0.1013	**0.7874**	0.1113
Relative variance in: ΔPCEU				
	1	0.0361	0.0363	**0.9276**
	3	0.1267	0.0765	**0.7968**
	6	0.1897	0.1353	**0.6750**
	10	0.2027	0.1389	**0.6584**
Kuwait				
Relative variance in: ΔRPCGDP				
	1	**1.0000**	0.0000	0.0000
	3	**0.4083**	0.0680	0.5237
	6	**0.2682**	0.1304	0.6014
	10	**0.1119**	0.1540	0.7341
Relative variance in: ΔCO_2				
	1	0.3665	**0.6335**	0.0000
	3	0.1227	**0.2571**	0.6202
	6	0.2345	**0.2103**	0.5552
	10	0.1470	**0.1931**	0.6599
Relative variance in: ΔPCEU				
	1	0.1207	0.0498	**0.8295**
	3	0.1387	0.1321	**0.7292**
	6	0.0986	0.1321	**0.7693**
	10	0.0660	0.1352	**0.7988**
Oman				
Relative variance in: ΔRPCGDP				
	1	**1.0000**	0.0000	0.0000
	3	**0.7895**	0.0601	0.1504
	6	**0.5579**	0.1748	0.2673
	10	**0.5361**	0.1697	0.2942
Relative variance in: ΔCO_2				
	1	0.0311	**0.9689**	0.0000
	3	0.0604	**0.8480**	0.0916
	6	0.0645	**0.7709**	0.1646
	10	0.0637	**0.7613**	0.1750

(Continued)

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Table 11. (*Continued*)

Percentage of variations in	Horizon	Due to innovation in		
		ΔRPCGDP	ΔCO_2	ΔPCEU
Relative variance in: ΔPCEU				
	1	0.0027	0.0010	**0.9963**
	3	0.0080	0.0076	**0.9844**
	6	0.0098	0.0193	**0.9709**
	10	0.0100	0.0203	**0.9697**
Qatar				
Relative variance in: ΔRPCGDP				
	1	**1.0000**	0.0000	0.0000
	3	**0.6634**	0.0149	0.3217
	6	**0.5740**	0.0223	0.4037
	10	**0.5593**	0.0238	0.4169
Relative variance in: ΔCO_2				
	1	0.0282	**0.9718**	0.0000
	3	0.0276	**0.8477**	0.1247
	6	0.0275	**0.8319**	0.1406
	10	0.0276	**0.8317**	0.1407
Relative variance in: ΔPCEU				
	1	0.0970	0.0675	**0.8355**
	3	0.1208	0.0650	**0.8142**
	6	0.1269	0.0640	**0.8091**
	10	0.1278	0.0639	**0.8083**
Saudi Arabia				
Relative variance in: ΔRPCGDP				
	1	**1.0000**	0.0000	0.0000
	3	**0.9447**	0.0060	0.0493
	6	**0.7311**	0.0686	0.2003
	10	**0.6481**	0.0746	0.2773
Relative variance in: ΔCO_2				
	1	0.0662	**0.9338**	0.0000
	3	0.0671	**0.9207**	0.0122
	6	0.0801	**0.8946**	0.0253
	10	0.0874	**0.8734**	0.0392
Relative variance in: ΔPCEU				
	1	0.0045	0.2509	**0.7446**
	3	0.1008	0.1905	**0.7087**
	6	0.1454	0.2382	**0.6164**
	10	0.1352	0.2409	**0.6239**
United Arab Emirates				
Relative variance in: ΔRPCGDP				
	1	**1.0000**	0.0000	0.0000
	3	**0.8163**	0.0051	0.1786
	6	**0.8005**	0.0309	0.1686
	10	**0.7877**	0.0330	0.1793

(*Continued*)

Table 11. (*Continued*)

Percentage of variations in	Horizon	Due to innovation in		
		ΔRPCGDP	ΔCO_2	ΔPCEU
Relative variance in: ΔCO_2				
	1	0.0280	**0.9720**	0.0000
	3	0.0638	**0.8111**	0.1251
	6	0.1289	**0.7498**	0.1213
	10	0.1356	**0.7424**	0.1220
Relative variance in: ΔPCEU				
	1	0.0971	0.0139	**0.8890**
	3	0.1021	0.0315	**0.8664**
	6	0.1245	0.0568	**0.8187**
	10	0.1291	0.0576	**0.8133**

Note: The figures in bold represent their own shocks.

conclusion, from the evidence of this paper, a strong case can be made for the efficacy of energy conservation. Energy is generally expected to play a major role in achieving economic, social, and technological progress and to complement labor and capital in production for Kuwait, Oman, and Qatar. Hence, to ensure sustainable economic growth, all these countries should invest in clean energies (renewable energy resources: solar and wind) and adopt measures of energy efficiency. Since global warming is becoming more serious, investment in renewable energies and more efficient energy use are needed to minimize the CO_2 emissions. At the same time, the different sectors must be encouraged to adopt advanced technology that minimizes pollution. Furthermore, energy-saving technologies and increased energy efficiency may increase the economic growth. Our results concord with policy recommendations of Cinti (2011), Omri (2013), Alshehry and Belloumi (2015), and Salahuddin et al. (2015). Cointegration results reveal that only for Saudi Arabia the hypothesis of a long-run relationship between these variables could not be rejected. With regard to the forecast error variance decomposition, the shocks in the energy use contribute more in explaining the forecast error variance in real GDP for Kuwait, Oman, Qatar, and Saudi Arabia. Meanwhile, the real GDP has a greater impact on the energy use only in Bahrain. Thus, these results strengthen the causality chain presented earlier, giving further support to the body of literature that suggests that energy use has a causal relationship with real GDP. While, in general, the impulse response function analyses suggest that the life of the exogenous shocks is different among the GCC countries, reinforcing our previous findings. However, these results are interesting, since they contrast to those of Al-Iriani (2006), and Shahateet (2014), which are based on panel data analyses. Our results significantly reject the assumption that energy is neutral for growth. This pattern is similar to the findings of Oh and Lee (2004), and Damette and Seghir (2013). The growth hypothesis—here confirmed for three countries—suggests that energy is a crucial component in growth, directly or indirectly as a complement to capital and labor as input factors of production. Hence, a decrease in energy consumption causes a decrease in real GDP. In this case, the economy is called “energy dependent,” and energy conservation policies may be implemented with adverse effects on real GDP. Therefore, if energy use Granger-causes economic growth, then energy conservation policies aiming at protecting the environment are expected to deteriorate the current stage of economic growth. Notwithstanding, since the causality results are different for the six GCC countries, unified energy policies would not be the good recipe for the whole area. Even though there may be political will to construct the common goals and objectives, different policy design for subgroups of member states ought to probably be considered.

7. Suggestions for future research

There is room for future research concerning GCC countries under this theme. For example, analysis at the disaggregated level is non-existent. Moreover, the environmental Kuznets curve (EKC) for GCC countries could be investigated.

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Notes
1. See the website: http://germanwatch.org/en/9472.
2. See the website: http://data.worldbank.org/data-catalog/world-development-indicators.
3. See the website: https://www.conference-board.org/data/economydatabase/.

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