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Abstract

This paper tests the electricity consumption-income growth hypothesis for the six member countries of the GCC. The paper uses the bounds test procedure suggested by Pesaran et al. (2001) to test for a long-run relationship and the non-causality approach suggested by Toda and Yamamoto (1995) to test for causality. This paper finds evidence of a long-run relationship between electricity consumption and economic growth for all GCC countries. Furthermore, it also finds support for the efficacy of energy conservation measures in five of the six countries, with Qatar the only exception. Economic interpretations, however, ought to be treated with caution due to the possibility of loss in power associated with the small sample size and potential omitted variable bias.

Keywords: GCC; electricity consumption; economic growth

1 Introduction

The Cooperation Council for the Arab States of the Gulf (GCC) was established in May 1981 and comprises: Bahrain; Kuwait; Oman; Qatar; the Kingdom of Saudi Arabia (KSA); and the United Arab Emirates (UAE). The GCC was established to "affect coordination, integration and inter-connection among the Member States in all fields in order to achieve unity."[1]

An interesting feature of this group is that four of the six countries: Kuwait; Qatar; KSA; and the UAE are also members of the Organization of Petroleum Exporting Countries (OPEC) and possess rich oil and gas reserves. Oman also has oil and gas reserves but is not a member of OPEC.[2] In contrast, Bahrain has virtually no reserves of oil or gas and does not generate any export earnings from the sale of hydrocarbons.

This means that the GCC Members provide an interesting sample of countries to test the electricity consumption-income growth hypothesis since four of the countries are members of OPEC, one, Oman, is also reasonably well endowed with energy, and one, Bahrain, is not well endowed at all. Therefore we may ask the following questions: to what extent do resource rich members of the GCC benefit from this rich resource endowment? Moreover, to what extent does their oil endowments translate into income generating electricity consumption?

Table 1 provides some relevant economic indicators to illustrate the extent of diversity amongst GCC members. Although this is a geographically contiguous group of countries on the Arabian peninsula, the countries range dramatically in size from the relatively large (KSA with more than 27 million people) to the very small (Bahrain with less than one million). Life expectancy is generally above 73 years with little variation amongst members. The literacy rate is above 75% for all countries and as high as 89% for Bahrain and Qatar. The percentage of arable land is very low for all six countries, most particularly for Oman, due to the high incidence of desert. Labor forces tend to vary with population, not surprisingly, but is a very small percentage of the population in

[1] Source: Cooperation Council for the Arab States of the Gulf, http://www.gcc-sg.org/Foundations.html

[2] According to the latest figures, Oman exports 721,000 barrels of oil per day and has reserves of 6.51 billion barrels. It also exports 7.43 billion cubic meters of gas per year and has gas reserves of 829.1 billion cubic meters (Source: CIA World Factbook: http://www.cia.gov/cia/publications/factbook/geos/mu.html).

the case of KSA. There is considerable dispersion in GDP per capita, measured in $US purchasing power parity terms with Qatar and the UAE experiencing very high, by world standards, income levels, Bahrain and Kuwait comfortable levels, but Oman and KSA lagging substantially. Another indicator of economic diversity, as well as, economic management, is public debt as a percentage of GDP, which is as high as 51.5% for Bahrain and as low as 7.5% for Oman. The final indicator, trade intensity, measured as X+M/GDP ranges from the more closed value of 68% for KSA to 169% for the UAE. For the oil exporting countries, these recorded trade intensity figures are, generally speaking, not as high as might be expected. Table 1 serves to emphasize the degree of diversity amongst GCC members in terms of their underlying economic structure, size and characteristics, for, what is otherwise, a fairly homogeneous group of countries. This group, therefore, provides an interesting sample to test the income growth-electricity consumption hypothesis.

Two strands are identified in the literature on the energy consumption-economic growth relationship. The first strand includes the supporters of energy consumption as a primary source of economic growth. Energy is generally expected to play a major role in achieving economic, social, and technological progress and to complement labor and capital in production (Dunkerley, 1992; Ebohon, 1996; Templet, 1999). The second strand considers energy to play a minimal or neutral role in economic growth and is commonly described as the "neutrality hypothesis" (Yu and Choi, 1985). This hypothesis is based on the contention that energy consumption should not affect economic growth because it represents too small of a proportion of a country's gross domestic product. It is further contended that as an economy grows, production should shift to less energy intensive service sectors (Wolde-Rufael, 2005). While the empirical literature investigating causality between electricity consumption and economic growth is quite large, it has been relatively silent with regards to GCC members. In fact, to date the previous literature is limited to a single study by Al-Iriani (2006) in which the author uses panel causality analysis and provides generalized results on GCC countries. In fact, the procedures used by Al-Iriani provide pooled causality evidence but no insight on causality for individual countries. This paper, therefore, aims to complement the current literature by analyzing the individual members of the GCC as a group of countries with strong

economic, cultural, and economic ties. The paper is organized as follows: Section 2 describes the data and empirical methodology. Section 3 summarizes the empirical results. Section 4 summarizes the results and concludes.

2 Empirical Methodology

The data used in this study are yearly and range between 1980 and 2003 and come from the United Nations Statistics Division (UNSD). The variables analyzed are, when applicable expressed in national currency, and include per capita electricity consumption and per capita real GDP which are derived using energy consumption, electricity, in kWh (millions) [code 17520]; GDP at market prices, current prices [code 19460]; GDP deflator, base 1990 [code 30201]; and Population total, estimates and projections (UN Population Division) [code 13660]. Because energy data are only available between 1980 to 2003, the empirical procedures are constrained to a small sample. Hence, any subsequent economic interpretations and corresponding policy implications must be treated with caution due to potential small sample and omitted variable biases.

Pesaran et al. (2001) suggest the use of an autoregressive distributed lag (ARDL) procedure or bounds test which does not require stationarity pre-testing and can be used regardless of whether the variables are I(0), I(1), or mutually cointegrated. This test is particularly appropriate for finite (or small) samples in which the order of integration is not known or may not be necessarily the same for all variables of interest. The bounds test is based on the following unrestricted error correction model (UECM):

$$\Delta E_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta E_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta Y_{t-i} + \phi E_{t-1} + \eta Y_{t-1} + \epsilon_t \tag{1}$$

where E_t denotes per capita electricity consumption and Y_t denotes per capita real GDP, both expressed in natural logarithm. The null hypothesis for no cointegration between electricity consumption and economic growth is:

$$H_0 : \phi = \eta = 0 \tag{2}$$

The bounds test is completed by first estimating equation (1), then re-estimating the equation after excluding in turn E_{t-1} and Y_{t-1}. An F-statistic is then computed and compared to the

non-standard critical bounds values reported in Pesaran et al. (2001). If the computed F-statistic exceeds the critical upper bounds value, then the null hypothesis of no cointegration is rejected. If the computed F-statistic falls below the critical lower bounds value, then the null hypothesis of no cointegration is not rejected. If the computed F-statistic falls between the critical lower and upper bounds values, then no conclusion can be drawn about cointegration without knowing the order of integration of the variables of interest. The appropriate lag structure is determined using the Akaike Information Criterion (AIC) (Wolde-Rufael, 2005). Furthermore, an error-correction term may be included as an explanatory variable in the constrained estimation of equation (1) to get an assessment of how quickly the relationship between electricity consumption and growth reverts to its long-run path.[3]

Causality between electricity consumption and economic growth can be completed using a modified Wald test (MWT) as suggested by Toda and Yamamoto (1995). This test is similar to the bounds test in the sense that it does not require prior knowledge of the order of integration of the variables of interest and is even applicable when cointegration does not exist (Zapata and Rambaldi, 1997). The approach suggested by Toda and Yamamoto (1995) uses a VAR model in the levels and augments the appropriate VAR order k by the maximum order of integration d. Unlike other procedures, such as Granger Causality and Johansen-Juselius, this test is less sensitive to problems with the residuals in finite samples (Toda and Yamamoto, 1995; Zapata and Rambaldi, 1997).

The MWT is completed by estimating the following VAR system:

$$E_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} E_{t-i} + \sum_{j=k+1}^{d} \alpha_{2j} E_{t-j} + \sum_{i=1}^{k} \beta_{1i} Y_{t-i} + \sum_{j=k+1}^{d} \beta_{2j} Y_{t-j} + \epsilon_{1t} \tag{3}$$

$$Y_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} Y_{t-i} + \sum_{j=k+1}^{d} \gamma_{2j} Y_{t-j} + \sum_{i=1}^{k} \lambda_{1i} E_{t-i} + \sum_{j=k+1}^{d} \lambda_{2j} E_{t-j} + \epsilon_{2t} \tag{4}$$

The null hypothesis of no cointegration is not rejected when $\beta_{1i} = 0$ and $\lambda_{1i} = 0$. The VAR system is estimated using a seemingly unrelated regression procedure.[4] The lag structure of the VAR

[3]The error-correction term simply represents the residuals generated from an estimation of the levels of per capita electricity consumption against per capita GDP or vice-versa.

[4]See for example Rambaldi and Doran (1996) and Wolde-Rufael (2005).

system is determined using Akaike Information Criteria and a standard Wald statistic, distributed as a Chi square, is computed given a number of constraints (equal to the degrees of freedom).

3 Results

A preliminary look at the line plots, in Figure 1, for per capita electricity consumption and per capita real GDP reveals a structural change in the series for Kuwait which is associated with the Gulf War of 1991, and thus a dummy variable taking a value of 1 in 1991 and 0 otherwise is introduced. A visual inspection of Figure 1 also shows that for Oman, per capita electricity consumption and per capita real GDP converge toward one another over time, intersect and diverge around 1992. This is indicative that per capita electricity consumption is growing at a much higher rate than per capita real GDP. This could be simply caused by population growth. Bahrain's per capita electricity consumption and per capita GDP appear to diverge from the beginning of the data range with no clearly discernible pattern. Qatar's series look relatively flat with no noticeable changes in the gap between the two series. KSA and the UAE look relatively similar and exhibit concurrent increases in per capita electricity consumption and decreases in per capita real GDP.

The appropriate lag structure is determined by completing regressions of equation (1) using one lag and then two lags. As shown in Table 2, one lag is determined to be appropriate for Oman, Qatar, and the UAE, two lags for Bahrain and Kuwait, and three lags for KSA.[5] The results, as summarized in Table 3, show that a long-run relationship exists between electricity consumption and real GDP for all GCC countries. The lagged error correction terms range between statistically insignificant coefficient estimates for Bahrain, Kuwait, and Oman and statistically significant coefficient estimates for Qatar (-0.26), KSA (-0.29), and the UAE (-0.45) indicating the percentage of adjustments toward a long-run equilibrium that occur within a year.

We summarize the non-causality tests in Table 4 in which we find that per capita real GDP causes per capita electricity consumption for all countries except the UAE. Causality is positive for Bahrain, Kuwait, Oman, and Qatar and negative for KSA. We also find that per capita electricity

[5]Three lags are tested to validate the choices of one or two lags, resulting in the analysis of KSA requiring three lags as opposed to other GCC members.

consumption negatively causes per capita real GDP for Bahrain and KSA and positively causes per capita real GDP for Qatar.

4 Summary and Conclusions

The diversity in the pattern of the results is somewhat surprising, though maybe explained by the diversity of the economic and social indicators summarized in Table 1. Whereas there is considerable social and ethnic homogeneity amongst these six countries, since they all belong to the GCC, and four are also OPEC members, there are, nevertheless, several important differences which will impact the electricity consumption-economic growth relationship. Of the six countries, Bahrain is clearly the most different in the sense that it is not richly endowed with hydrocarbons. Its causality test results though are similar to KSA's, the most richly resource-endowed country. Bahrain and KSA are the only countries to record a positive and statistically significant income to electricity relationship and negative and significant electricity to income relationship. This suggests an unusual endogeneity in that income growth leads to increased energy consumption which feeds back into negative income growth. These results tend to support the efficacy of increased energy conservation in the case of Bahrain and KSA, since such conservation would help eliminate a negative feedback upon income growth.

Kuwait and Oman, two resource rich countries, record significant and positive income to electricity consumption relationships, but no significant electricity consumption to income relationship. This suggests that energy conservation would have little or no impact upon income growth in each of these countries. Qatar records a positive and significant income to electricity consumption relationship and a positive and significant electricity consumption to income relationship. These results suggest a positive endogenous relationship whereby increased incomes lead to higher electricity consumption, which leads to further income growth. Hence, on the basis of these results, energy conservation measures may retard income growth in Qatar.

The UAE also records an interesting set of results. It is the only country in the group to record no significant income to electricity consumption relationship and no significant electricity

consumption to income relationship. These results indicate that energy conservation measures may indeed have no impact on income growth in the UAE. Of all the GCC members, the UAE is the most advanced in its economic diversification strategies and the oil and gas sector contribution to GDP is on a downward path and has recently fallen to less than 30%.

In conclusion, from the evidence of this paper, a very strong case can be made for the efficacy of electricity conservation in the cases of Bahrain and KSA; a good case for conservation can be made for Kuwait and Oman. A weaker case for energy conservation could be made for the UAE but no such case can be made for Qatar. These interpretations, however, ought to be treated with caution due to the possibility of loss in power associated with the small sample size and potential omitted variable bias.

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Table 1: GCC Economic and Social Indicators

Country	Population (millions)	Life Expectancy (at birth years)	Literacy (%)	Arable Land (%)	Labor Force (millions)	Per capita GDP PPP (USD)	Public Debt/GDP (%)	(X+M)/GDP (%)
Bahrain	0.69	74.45	89.10	2.82	0.38	20,500	51.50	151.57
Kuwait	2.41	77.20	83.50	0.84	1.67	22,800	17.60	88.24
Oman	3.10	73.37	75.80	0.12	0.92	13,200	7.50	89.07
Qatar	0.88	73.90	89.00	1.64	0.44	26,100	36.70	87.50
KSA	27.01	75.67	78.80	1.67	6.76	12,900	41.00	68.55
UAE	4.32	75.44	77.90	0.77	2.80	29,100	17.50	169.80

Data come from the CIA Factbook url: http://www.cia.gov/cia/publications/factbook/ except for the UAE population number which comes from the UAE Central Bank Annual Report 2004. (X+M/GDP) numbers come from the World Bank's World Development Indicators, except for Qatar and the UAE which come from Lopez-Claros et al. (2005).

Table 2: Choice of Lag Structure

	AIC(-2)	AIC(-1)	Appropriate Lag
Bahrain	-3.20	-3.25	2
Kuwait	-1.18	-1.13	2
Oman	-3.60	-3.72	1
Qatar	-3.27	-3.46	1
KSA	-2.05	-1.75	3*
UAE	-3.39	-2.72	1

Due to the small sample size, a maximum of two lags. Although the AIC for the UAE is smaller when using two lags, only one lag is selected because the adjusted-R^2 is equal to -0.17 when using two lags and 0.30 when using one lag. The asterisk describes a situation in which three lags are tested as a way to identify the validity of limiting the lag structure to two, which results in the analysis of KSA requiring three lags as opposed to other members of the GCC.

Table 3: Bounds Test Results

	F-Stat with trend	F-Stat	ECM(-1)	Long-Run Relationship
Bahrain	4.53	5.13***	-1.5e-05	Yes
Kuwait	3.68**	17.14***	-0.46	Yes
Oman	22.92***	23.64***	-1.12e-05	Yes
Qatar	5.74***	3.63*	-0.26**	Yes
KSA	6.00***	15.00***	-0.29**	Yes
UAE	5.47***	4.55***	-0.45**	Yes

The critical values are derived from tables CI(iii) and CI(iv) of Pesaran et al. (2001), respectively for case III: unrestricted intercept and no trend and case IV: unrestricted intercept and restricted trend. Asterisks, ** and *** denote statistical significance respectively at the 0.05 and 0.01 levels.

Table 4: Toda and Yamamoto Non-Causality Test Results

	Y to E		E to Y		
Country	Wald Stat	Sum of lagged Coef.	Wald Stat	Sum of lagged Coef.	Causality
Bahrain	15.06***	0.51	20.95***	-0.50	Y↔E
Kuwait	12.30***	0.29	3.12	-0.88	Y→E
Oman	26.89***	1.01	4.59	-0.04	Y→E
Qatar	13.48***	0.49	6.32**	0.15	Y↔E
KSA	24.49***	0.07	21.43***	-0.32	Y↔E
UAE	1.43	0.05	5.62	-0.23	No

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). Asterisks, ** and *** denote statistical significance respectively at the 0.05 and 0.01 levels.

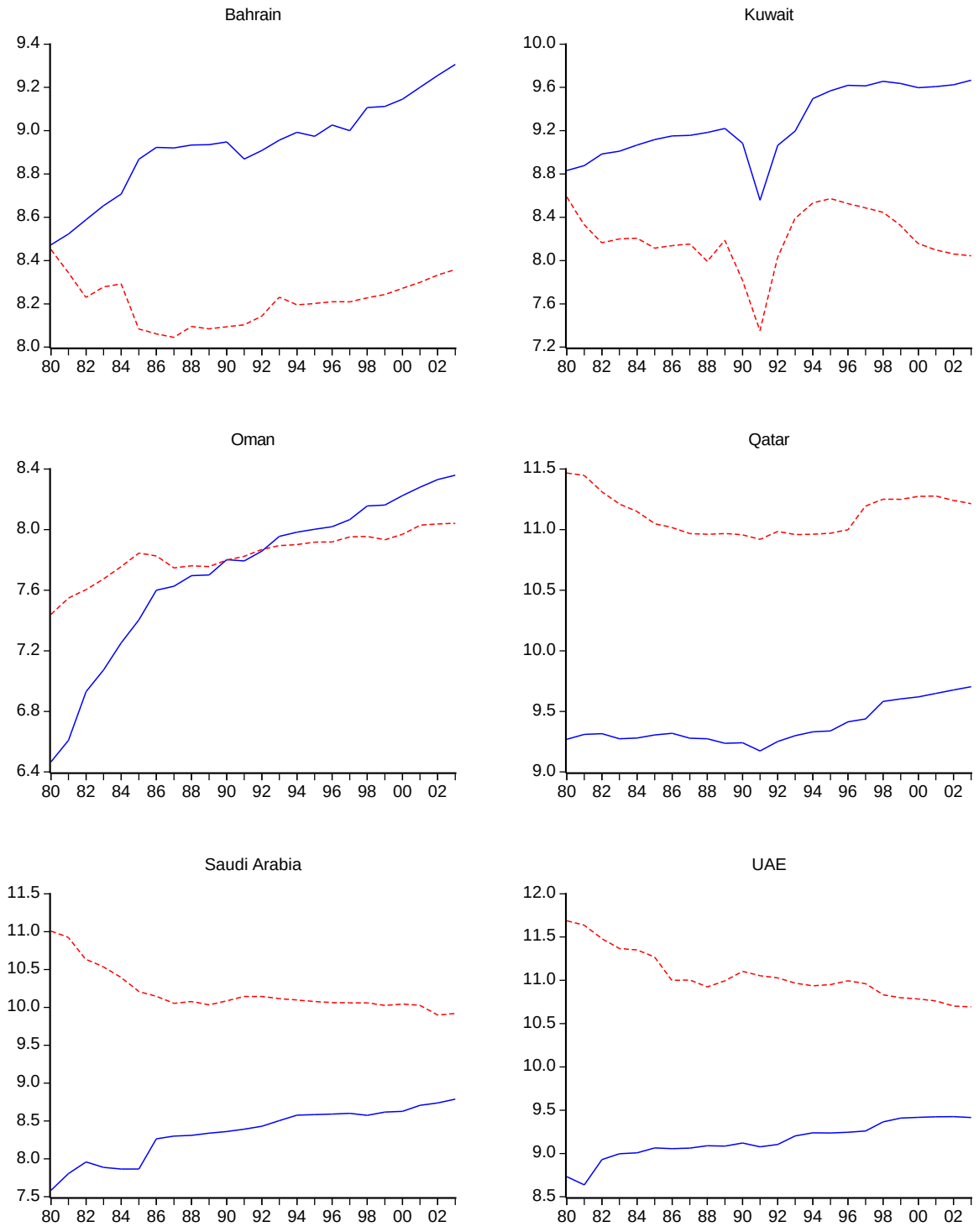

Figure 1: Per capita Electricity Demand (solid line) and Real GDP (dashed line)