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Economic Growth and its Impact on Energy Consumption and Energy Intensity of Use

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Abstract

The purpose of this paper is to analyze the relationship between energy consumption and economic growth in Saudi Arabia and United Arab Emirates for the period 1990-2010. The paper will also assess the impacts of changes in energy prices on aggregate energy consumption, and finally, the paper will analyze the relationship between economic growth and oil intensity of use. We used time series data to provide estimates of elasticities. Empirical results showed: (1) The impact of income on energy consumption is positive, but with low elasticities. (2) The impacts of energy prices showed no significant effect on restraining total energy demand in both countries. (3) The effect of GDP on intensity of use for Saudi Arabia is positive indicating a high price or cost of converting energy into GDP while it is negative for United Arab Emirates, indicating a lower price or cost of converting energy into GDP. The paper concludes that United Arab Emirates is using its energy more efficiently compared to Saudi Arabia, which means that it uses less energy to perform the same task compared to Saudi Arabia, which implies that improving energy efficiency for Saudi Arabia is essential for more sustainable development in the future.

JEL classification numbers: O4
Keywords: Energy economics, economic growth

1 Introduction

The purpose of this paper is to analyze the relationship between energy consumption and economic growth in Saudi Arabia and United Arab Emirates for the period 1990-2010. During most of this period there were rapid increases in the price of imported fuel in all

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countries around the world.
First, we analyses the relationship between energy consumption and economic growth for energy consumption. Rapid economic growth in LDC's generally contributes to large increase in energy demand Pindyk (1979). Second, we analyze the country's intensity of use of energy for both countries to investigate how intensity varies with income and changes in this relationship across time. High energy intensities indicate a high price or cost of converting energy into GDP, while low energy intensity indicates a lower price or cost of converting energy into GDP, Paul Chefurka (2007).

2 Hypothesis and Methodology of the Study

To test the hypothesis that economic growth will have a positive and significant impact on energy consumption and oil intensity of use, an econometric model will be used. The methodology of the study consists of estimating the energy demand and energy intensity of use. The estimations will include gross national products and energy prices in both countries.

3 Energy Consumption and Economic Growth

There was a strong relationship between gross domestic product and the demand for energy before the energy crisis of 1973, and energy predictions were based on this strong relationship. Of course, this relationship changed after 1973 when petroleum prices changed significantly. Those price changes brought changes in the development structure of the world economy, especially in the industrial countries. These changes favored products and industries that use less energy, and this in turn generally decreased the consumption of commercial energy per unit of GNP.
The relationship between income (GDP) and commercial energy consumption in the two countries can be described more formally by estimating the income elasticity of demand through regression analysis. The income elasticity gives the percentage increase in energy consumption associated with a given percentage increase in GDP.
In the last twenty years, the total primary energy consumption, for both Saudi Arabia and United Arab Emirates, have gradually increased growing at an annual rate of 4.7 % and 3.4 % respectively, figure 1. The annual growth rate is computed from equation (1) and (2) as the antilog of the coefficient of the trend variable (a) minus one:

$R = (e^a-1)\ (100)$
Given $a = 0.046$
$R = (e^a-1)\ (100) = 4.7\ \%$

$$\text{LOGCONS} = 1.12 + 0.046\ t \qquad (1)$$
$$(64)\quad (30)$$
$R^2 = 0.98$, D-W = 0.47, (1990 – 2010)

$$\text{LOGCONS} = 0.23 + 0.04152\ t \qquad (2)$$
$$(8)\quad (19)$$
$R^2 = 0.95$, D-W = 0.93, (1990 – 2010)

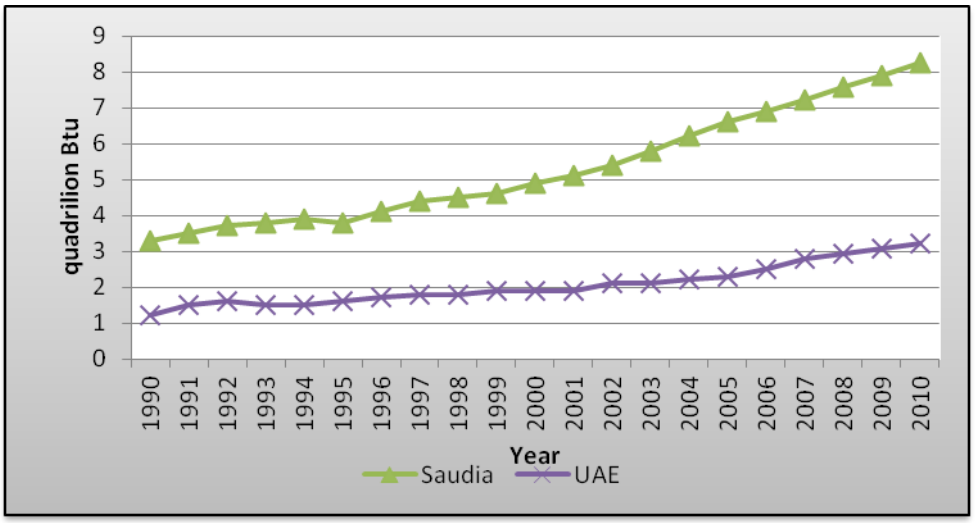

Figure 1: Total primary energy consumption (quadrillion btu)

Based on the results of equation (3) and (4), presented below, with t statistic in parenthesis and after correcting for autocorrelation, the log log simple model is employed, which proved to fit the data well. All coefficients are statistically significant and well determined at the 5% level of significance.

LOGCONS = - 5.282 + 0.563 LOGGDP Saudi Arabia (3)
(-13) (17)
R^2 = 0.94, D-W=0.36, (1990-2010)

LOGCONS = - 3.265 + 0.351 LOGGDP United Arab Emirates (4)
(-14) (17)
R^2= 0.94, D-W= 1.2, (1990-2010)

Both equations show that about 94 % of the variation in the demand for energy, for both countries, is explained by income. The impact of income on energy consumption is indicated by the inelastic elasticities of (0.56) and (0.35), which are evaluated at the mean of GDPs. These values implies that as income increases by one percent, energy consumption, in both countries, are increased by 0.66 % and 0.59% respectively.
Although, the values of R^2 are high for both countries, the values of the D-W statistics are still low, even after the Cochran Orcutt correction for autocorrelation. This result indicates that, beside the gross domestic product there are some other factors that affect the demand for commercial energy in Saudi Arabia and United Arab Emirates. So, the result above is measuring only the relationship between (GDP) the gross domestic product and commercial energy consumption when the effects of other factors are omitted from the equation. The preferred solution to the autocorrelation problem is to include the missing variables in the model. This is examined in the coming sections.

4 The Effect of Price on Energy Demand

Because of data limitation, the price of gasoline, in both countries, were used as proxies to test the effect of energy prices on energy demands during the study period. The price of energy in both countries were relatively constant over most of the period, especially in Saudi Arabia, which might have no significant effect on restraining total energy demand, figure 2.

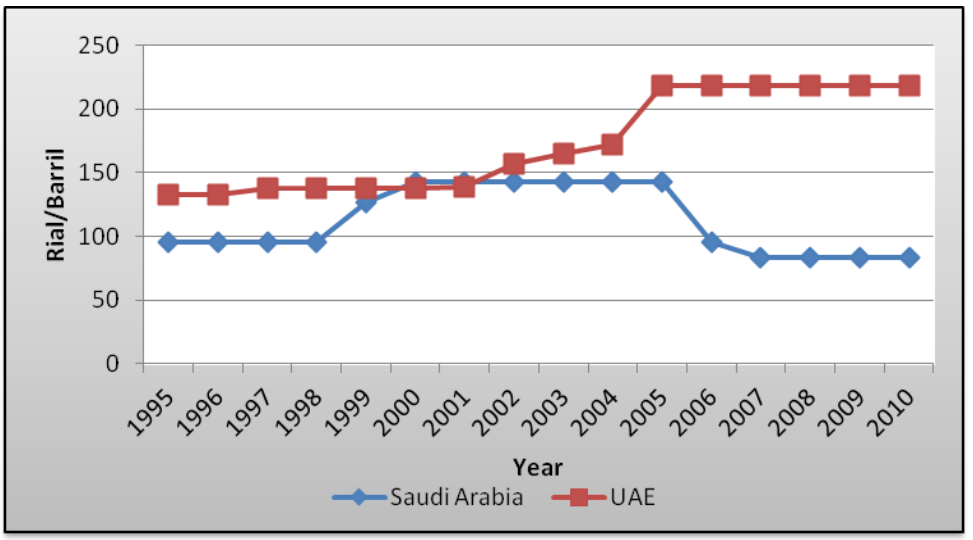

Figure 2: Gasoline prices1995 - 2010

All equations were re-estimated using the ordinary least square (OLS) with t-ratios in parentheses under the corresponding coefficient estimates, equation (5) and (6) for Saudi Arabia and United Arab Emirates, respectively.

LOGCONS = - 6.17 + 0.55 LOGGDP + 0.22 LOGPRICE (5)
(-17) (20) (4)
R^2= 0.97, D-W= 1.6, (1995-2010)

LOGCONS = - 2.69 + 0.38 LOGGDP - 0.18 LOGPRICE (6)
(-10) (7) (-1.2)
R^2= 0.97, D-W= 1.9, (1995-2010)

Examining this result, all estimated coefficients are highly significant at the 5 % level except that for price of energy in United Arab Emirates, which shows no significant effect on restraining total energy demand. The coefficient of price was estimated with elasticity of (-0.18), although it has the correct sign, it is not significant at the 5% level; nevertheless it was kept in the estimated equation for conceptual completeness.
Different result was found in the case of Saudi Arabia. Although the price of energy is significant at the 5% level, its sign found to be positive, which is different from the conceptual theory, with elasticity of (0.22). The actual and fitted total energy consumption, for both countries, is depicted in figure 3 and 4 respectively.

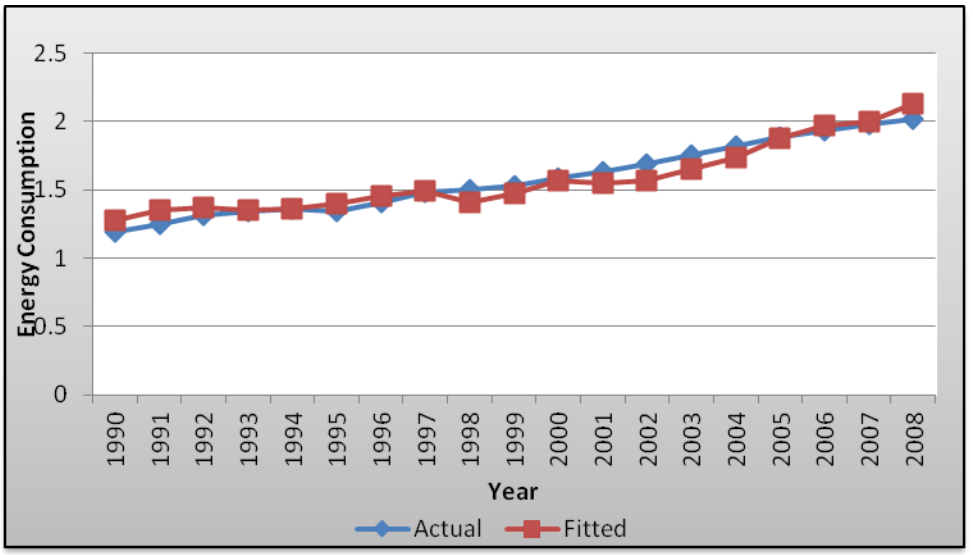

Figure 3: Total primary energy consumption in Saudi Arabia (quadrillion btu)

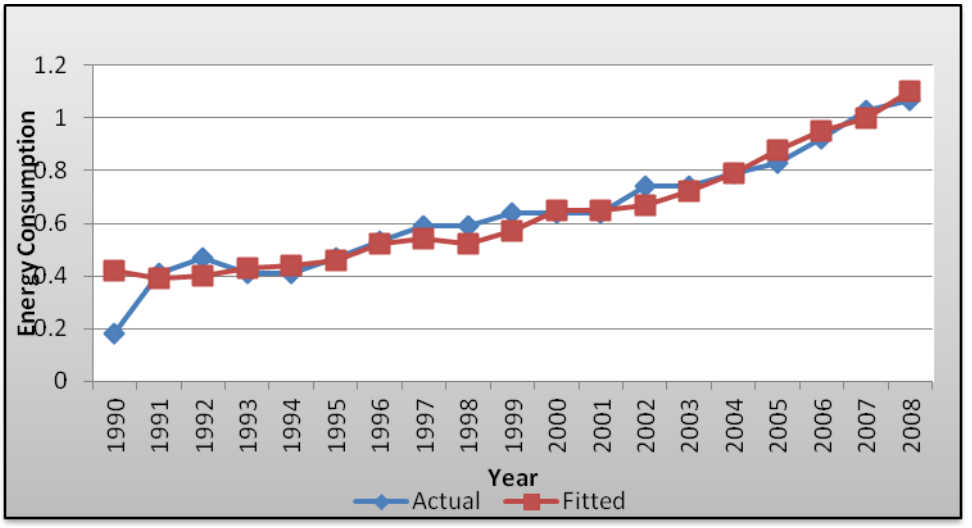

Figure 4: Total primary energy consumption in Saudi Arabia (quadrillion btu)

5 Energy Intensity of Use

Energy intensity of use is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP. It is the amount of energy it takes to produce a dollar's worth of economic output. This value varies widely between countries, depending on their level of industrialization, the mix of services and manufacturing in their economies, and the attention they pay to energy efficiency.

Mathematically, intensity of use (IU) is calculated according to the following simple model:

IUt = Dt/Yt
Where:
IUt = Intensity of use at time t.
Dt = Total demand for energy at time t.
Yt = Total GDP at time t.

In the last two decades, the energy intensity of use for both countries have different trends. While intensity of use in Saudi Arabia was increasing at an annual rate of (2%), the energy intensity of use in United Arab Emirates was decreasing at an average rate of (–2.7%) annually, figure 5.

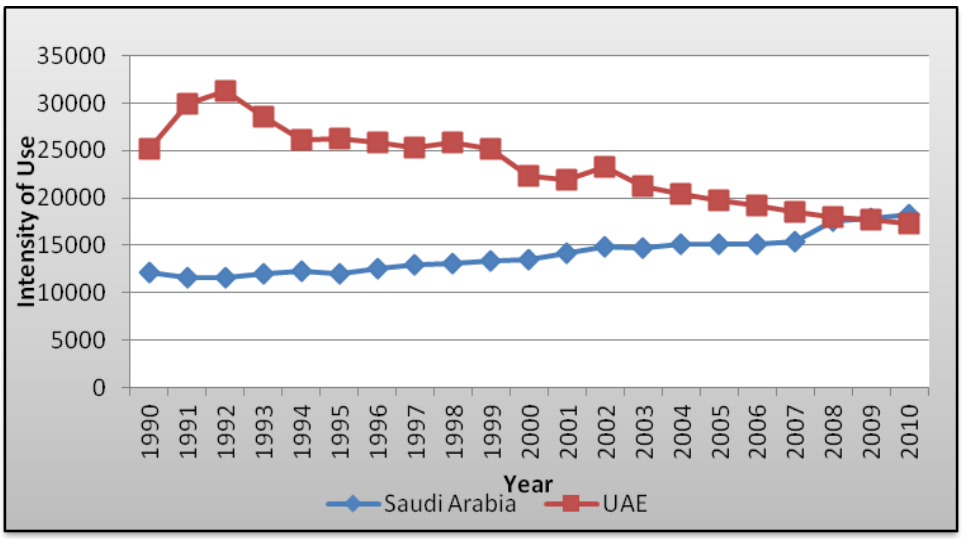

Figure 5: Ratio of energy consumption to GDP, (btu per (2000) U.S. dollars)

The relationship between intensity of use and GDP is described by equation (7) and (8), which after correction for autocorrelation, the log log model fits the data satisfactorily and showed positive effect of GDP (economic growth) on intensity of use with an income elasticity of (0.27) in the case of Saudi Arabia, whereas it has a negative effect in the case of United Arab Emirates with an elasticity of (-0.24).

LOGINTNS = 6.266+ 0.267 LOGGDP (7)
(25) (13)
R^2 = 0.90, D-W= 0.79, (1990-2010)

LOGINTNS= 12.695 – 0.236 LOGGDP (8)
(76) (-16)
R^2 = 0.93, D-W=1.23, (1990-2010)

These results indicate the extent to which the ratio of energy consumption to GDP is increasing or decreasing as income increases over time. Figures 6 and 7 showed these relationships respectively.

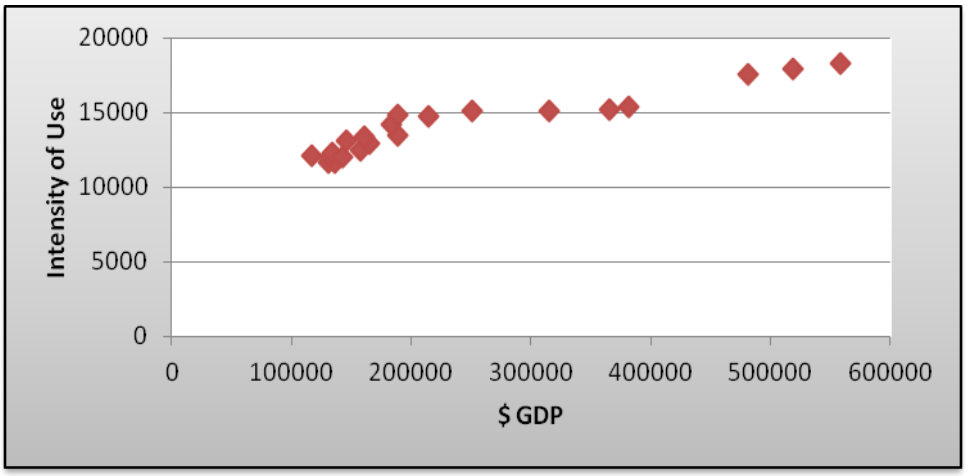

Figure 6: Intensity of use vs GDP- Saudi Arabia(btu per 2000 U.S. dollar), 1990 –2010

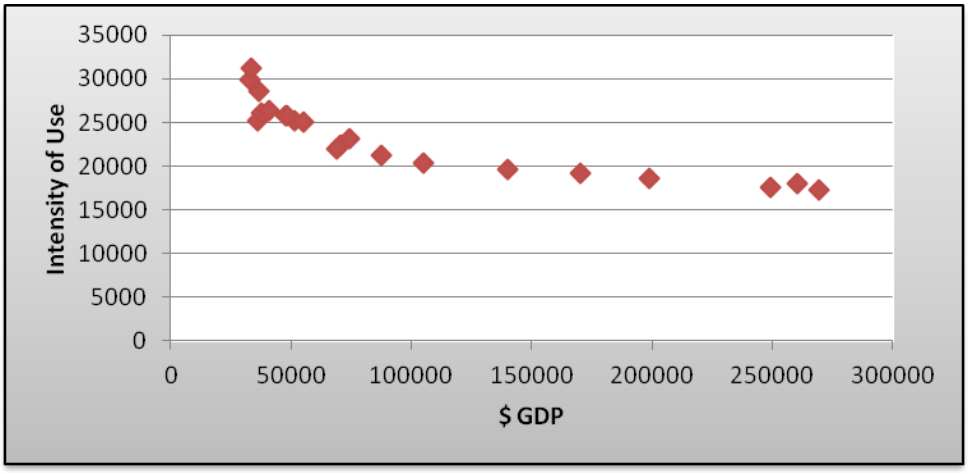

Figure 7: Intensity of use vs GDP – UAE (btu per 2000 U.S. dollar), 1990 –2010

These results indicate that as income increases the overall intensity of use for petroleum in Saudi Arabia increased for the whole period, whereas the overall intensity of use for petroleum in United Arab Emirates decreased over the whole period.

6 Research Findings

In general, our finding shows that economic growth is the main factor in explaining changes in the demand for commercial energy, although elasticity of demand with respect to (GDP) is less than one for the two countries under this study. Although, the values of R^2 are high, the values of the D.W. statistics, are still low, even after the Cochran Orcutt correction for autocorrelation. This result indicates that, beside the gross domestic product there are some other factors that affect the demand for commercial energy in the two countries. The preferred solution to the autocorrelation problem is to include the missing variables in the model.

When the price of energy were introduced into the equations, the coefficient of price of energy in United Arab Emirates was estimated, although it has the correct sign, it is not significant at the 5% level; nevertheless it was kept in the estimated equation for conceptual completeness. Different result was found in the case of Saudi Arabia. Although the price of energy is significant at the 5% level, its sign found to be positive, which is different from the conceptual theory.

The effect of GDP on intensity of use for Saudi Arabia is positive, which mean high energy intensity indicating a high price or cost of converting energy into GDP while it is negative for United Arab Emirates, which mean low energy intensity indicating a lower price or cost of converting energy into GDP.

This paper concludes that United Arab Emirates is using its energy more efficiently compared to Saudi Arabia, which means that it uses less energy to perform the same task compared to Saudi Arabia, which implies that improving energy efficiency for Saudi Arabia is essential for more sustainable development in the future.

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