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The Demand for Electricity in Kuwait: A Cointegration Analysis

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ABSTRACT

In this paper, we investigate the determinants of electricity demand in Kuwait and evaluate their impact on electricity consumption. In order to do this, we use the standard demand equation, cointegration techniques, and the error correction model on annual time series data for Kuwait from 1972 to 2017. One of the important features of our contribution is that it covers the most recently available data, in which we use the longest annual period (45 years) compared to all other studies of electricity demand in the region. We find that income elasticity for Kuwaiti consumers is insignificant both in short-run and the long run. This indicates that income has no impact on the consumption of electricity in Kuwait. Additionally, the short-run price elasticity is −0.22 while the long-run is −1.22, suggesting a negative yet elastic relationship between the electricity price in Kuwait and the demand in the long-run, while the short-run is inelastic.

Keywords: Electricity Demand, Structural Time Series Model, Cointegration
JEL Classifications: C22, Q41, Q43

1. INTRODUCTION

The discovery of oil has played a significant role in several sectors of development in Kuwait, including education, urbanization, health, and economics. Electricity services were one of the critical elements of improvement in the country. According to the Ministry of Electricity and Water of Kuwait, the first use of electricity in the country occurred in 1913. The consumption of electricity in Kuwait has increased sharply in the last few decades, growing from 7965 million kw/h (kWh) in 1980 to 45,234 million kWh in 2008 (6.4% yearly growth on average over this period), BuShehri and Wohlgenant (2012). The maximum electrical load in Kuwait significantly increased, with a yearly increase rate of 32% in the 1950s, 26% in the 1960s, 15% in the 1970s, and 8% in the 1980s. This increased rate is still high compared to those of most developed countries, which do not exceed 2% to 3% per year. It is also a direct reflection of the climate conditions, rapid economic growth, and urban development witnessed by Kuwait in both the public and private sectors. Therefore, there is a rise in per capita electricity consumption, which in turn reveals the existence of consumer spending encouraged by the low price of electricity, Eltony and Hoque (1996) and Al-Faris (2002).

It is believed that electricity subsidies are the main component of the vast increase in electricity consumption in Kuwait, with residents paying only 7.8% to 11% of the real cost of electricity. According to Gelan (2018), Kuwait's electricity prices are some of the lowest in the world. Hence, the government needs reform in this area to avoid any further burdens on the budget and reduce waste resulting from unreasonable consumption. However, pricing reform should follow a step-by- step plan to prevent any shocks in the market and avoid any resistance from the public. Over the past few years, several studies have examined the impacts of electricity subsidies on social welfare, the environment, and the government budget. Al-Faris (2002) studies the effects of price and income on electricity demand in the Gulf Cooperation Council (GCC) countries and finds that long-run price elasticity is greater than short-run price elasticity, meaning that price reforms will have a stronger effect over time. As time passes, consumers will have more flexibility to curtail their demand, either through conservation or through substitution in response to higher tariffs or taxes.[1] Eltony and Al-Awadhi (2007) estimate the energy demand of the household sector in Kuwait using the top-down or two-level approach. They simulate future energy demand under different policy options (i.e., different pricing). Wood and Alsayegh (2014) estimate the impact of oil prices and economic diversification on electricity and water demand in Kuwait. They find that every \$1 change in oil price will, on average, affect the demand for electricity by 0.13 gigawatts/h (GWh). Atalla and Hunt (2016) study the drivers of residential electricity demand in GCC countries using a structural time series model. They estimate an income elasticity of 0.30 in the short run and 0.43 in the long term. In addition, the real price elasticity is estimated to be zero, suggesting that the demand for electricity in Kuwait is perfectly price inelastic. Several other studies have investigated the topics related to electricity and subsidies in Kuwait and the surrounding regions, including the GCC countries and the Middle East and North Africa (MENA) in the literature. Table 1 summarizes the estimates of income and the price elasticities in these articles.

In this paper, we investigate the determinants of electricity demand in Kuwait and evaluate their impact on electricity consumption. We use standard demand equation, cointegration techniques, and the error correction model on annual time series data for Kuwait from 1972 to 2017. Our findings show that income is not a significant factor in explaining electricity consumption. Moreover, we find that price elasticity of electricity demand is inelastic in short-run, while it is elastic in the long run. The contribution of this paper is twofold. First, we use the most recent dataset for electricity demand in Kuwait. Second, unlike other electricity demand studies on Kuwait, we compute that income elasticity is not statistically significant from zero both in short-run and the long run.

The rest of the paper is organized as follows. We present the data, the empirical model, and discuss our findings in Section 2. Section 3 concludes and discusses policy recommendations.

1 The GCC countries are Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman

2. DATA, EMPIRICAL MODEL, AND FINDINGS

We begin our analysis with a log-linear demand model, which relates electricity consumption to its own price and a measure of economic activity. Our model could take the general form as follows:

$$Consumption_t = \beta_0 + \beta_1 GDP_t + \beta_2 Price_t + \varepsilon_t \quad (1)$$

Where $Consumption_t$ is the per-capita electricity consumption, GDP_t represents the measure of economic activity (real GDP per capita), and $Price_t$ is the real price of electricity.

Table 2 displays the principal measures of electricity in Kuwait. We note a steady rise in per capita electricity consumption from 1976 through 2016. The table also contains another significant metric, electricity intensity or electricity consumtion/GDP ratio, which is the energy required to produce an output unit. This ratio exhibits a constant increase over the entire period indicating, to a large extent, higher levels of growth in electricity consumption compared to levels of economic growth. Kuwait's electricity intensity is much higher than the countries with comparable or higher per capita income, which designates the existence of waste and significant power-sector losses.

We use annual time series covering a period of time from 1972 to 2017. Residential electricity consumption is taken from the Organization of Arab Petroleum Exporting Countries (OAPEC) database. Prices of residential electricity are utilized by the Ministry of Electricity and Water in Kuwait (MEW). The World Bank Development Indicators database serves as the source of data concerning GDP in current U.S. prices, the total population series, and the consumer price index (CPI). We compute real GDP by dividing nominal GDP by CPI and per capita real GDP by dividing real GDP with the population.

Table 3 provides summary statistics for the variables. The economic growth fluctuates from −34.15% to 100.39% with an overall mean of 1.78%. There is a considerable variation in electricity consumption. It has a mean of 9838.20kWh, while ranging from 3011.95kWh to 14062.59kWh. Likewise, the real price of electricity has a mean of \$0.0010 and goes from \$0.0005 to \$0.0016.

Table 4 displays the unit root test results for the variables used in our analyses, where we implement Augmented Dickey-Fuller

Table 1: Estimates of price and income elasticities of residential electricity demand

Paper	Country period	Data type	Price elasticity		Income elasticity	
			Long run	Short Run	Long Run	Short Run
Al-Qudsi (1989)	Kuwait 1977/79 and 1986/87	Cross-sectional	-	-	0.30	-
Eltony and Mohammad (1993)	Kuwait (GCC) 1975-1989	Panel data	−0.14	-	0.20	-
Eltony (1995)	Kuwait 1975-1992	Time series	−0.06	-	0.09	-
Eltony and Hoque (1996)	Kuwait 1975-1994	Time series	−1.97	−1.09	0.65	0.57
Al-Faris (2002)	Kuwait (GCC) 1970-1997	Time series	−1.10	−0.08	0.33	0.70
Eltony and Al-Awadhi (2007)	Kuwait 1975-2005	Time series	−0.56	−0.23	0.32	0.18
Narayan and Smyth (2009)	Kuwait (MENA) 1974-2002	Panel data	-	-	−1.32	-
BuShehri and Wohlgenant (2012)	Kuwait 2000	Cross-sectional	−0.15-−0.27	-	0.18-0.43	-
Atalla and Hunt (2016)	Kuwait (GCC) 1985-2009	Time-series	-	-	0.68	0.30

This table displays the studies which estimate the price and income elasticities of electricity demand for Kuwait in the literature

Table 2: Electicity indicators in Kuwait

Variable	1976	1986	1996	2006	2016
Electricity cons (gWh)	4767	15665	22673	42170	61925
Electricity cons/GDP (gWh/US$ 2011)	0.042	0.173	0.170	0.182	0.221
Electricity cons (kWh per capita)	4376.57	8531.65	10828.18	13248.67	14038.37

This table reports the electricity indicators in Kuwait

Table 3: Descriptive statistics

Variable	Unit	Mean	Std. dev	Min	Max
GDP growth (per capita)	%	1.78	23.58	−34.15	100.39
Electricity consumption (per capita)	kWh	9838.20	3604.71	3011.95	14062.59
Electricity real price	USD	0.0010	0.0003	0.0005	0.0016

This table reports mean, standard deviation, minimum, and maximum for the variables used in the analyses. Sample runs from 1972 to 2017

(ADF), Dickey-Fuller GLS, and Phillips-Perron in the levels and first differences for the variables - electricity consumption, GDP and price of electricity. In all tests, we include an intercept and a trend term. All unit root tests indicate that we fail to reject the null hypothesis of the unit root (non-stationary) for all the variables in the levels. When we take the first difference of the variables, we reject the null hypothesis of unit root at 1% significance level and we conclude that electricity consumption growth, GDP growth, and inflation of electricity (the price of electricity growth) are stationary.

It is well known that a large number of macroeconomic time series are non-stationary. If a series is non-stationary, it has a unit root and said to be integrated of order one (I(1)). When we have several macroeconomic time series and their linear combination is stationary (I(0)), then these variables are said to be cointegrated. As a next step, we investigate whether a combination of electricity consumption, GDP and price of electricity could be of the order I(0) or, in other words, cointegrated. We implement the cointegration techniques developed by Johansen (1988) and Johansen and Juselius (1990). These techniques employ the maximum likelihood estimation procedure to determine the presence of cointegrating vectors in non-stationary time series and detect the number of cointegrating vectors, which allow testing the hypothesis regarding elements of the cointegrating vector. For the Johansen cointegration test, the null hypothesis is that the number of cointegrating vectors is at most r, where r equals 0, 1, or 2. The null hypothesis is put to the test against the general alternative for each case.

Table 5 displays our findings from the cointegration test, which includes our three variables for Kuwait. The trace statistic is statistically significant at 5% level when $r = 0$ and is not significant when $r \leq 1$. Therefore, there is only one cointegrating relationship at 5% level. We conclude that the null hypothesis of no cointegrating relationship is rejected and there is evidence of a stationary long-run equilibrium between electricity consumption, GDP, and electricity price.

The results of the unit root and cointegration tests indicate that demand for electricity, national income and price of electricity can be represented by the error-correction model (ECM). We write the error correction model as follows:

$$\Delta Consumtion_t = \gamma_0 + \gamma_1 \Delta GDP_t + \gamma_2 \Delta Price_t + \gamma_3 \varepsilon_{t-1} + u_t \quad (2)$$

where *Consumption*, *GDP* and *Price* are defined in equation (1) above, ε_{t-1} is the lag of the estimated residuals from the long-run demand equation in (1), and its coefficient γ_3 represents the speed of adjustment to the equilibrium.

Table 6 displays the estimated short-run coefficients and the corresponding test statistics from the error-correction model. Since we employ a log-linear model for the electricity demand, our coefficient estimates may well be interpreted as the income and own-price elasticity of demand. Both income and own price elasticity estimates have the expected signs. We find that own price elasticity coefficient is significant at the 10% level. Our error correction model shows that a 10% increase in the price of electricity decreases the demand for consumption about 2.2%. So, the demand for electricity in Kuwait is inelastic with respect to prices in the short-run. On the other hand, income elasticity of demand for Kuwait has the right sign but not significant. Kuwait's estimated short-run income elasticity is 0.035, highlighting the fact that most Kuwaiti citizens find electricity consumption as a necessity. Moreover, the short-run model shows that electricity consumption adjusts towards its long-run equilibrium level at a low speed, with about 8.7%. Table 6 also reports the coefficient of determination R^2 as 22%, which demonstrates that the variables jointly explain 22% of the variation in the change in electricity consumption. LM test display the probability value from the Breusch-Godfrey Lagrange multiplier test for serial correlation in the residuals. The null hypothesis for the LM test is that there is no serial correlation in the residuals up to the fifth order. The probability value of the LM test is 0.61. Therefore, we fail to reject the null hypothesis of no serial correlation in the residuals.

Table 7 exhibits our finding from the long-run error correction model. Our long-run estimates could be interpreted as the long-run elasticities of own-price and income. As expected, we find that price elasticity is more abundant in the long-run than in the short-run. The long-run price elasticity of electricity demand is elastic with an estimate of −1.22. However, the coefficient of income elasticity is not statistically significant, which indicates that income elasticity is not different from zero. Consequently, we could argue that the citizens of Kuwait consider electricity as a necessity even in the long-run.

Table 4: Results of unit root tests

	ADF test statistic		DF-GLS test statistic		Phillips Perron test statistic	
	Level	First difference	Level	First difference	Level	First difference
Consumption	−2.231	−4.801***	−1.650	−5.072***	−2.236	−4.733***
GDP	−1.953	−5.738***	−1.903	−5.800***	−2.104	−5.711***
Price electricity	−2.195	−5.479***	−1.955	−5.405***	−2.283	−5.435***

This table reports the test results from the Augmented Dickey Fuller (ADF), Dickey-Fuller GLS (DF-GLS), and Phillips-Perron unit root tests. ***, **, and * indicates significance at 1%, 2.5% and 10% level, respectively

Table 5: Johansen cointegration test

	$r=0$	$r\leq 1$
Trace statistic	47.253	19.883
Probability	0.017	0.232

This table reports the trace test statistic for the Johansen cointegration test. r is the hypothesized number of cointegrating equations

Table 6: Short-run results of error correction model

Dependent variable: Δ*Electricity consumption*$_t$		
	Coefficient	Probability
ΔGDP_t	0.035	0.343
$\Delta Price_t$	−0.219	0.079
$Error_{t-1}$	−0.087	0.012
R^2		0.22
LM test		0.61 (prob)
Observations		44

This table reports the short-run results of the error correction model. LM test is the lagrange multiplier test for serial correlation

3. CONCLUSION AND POLICY IMPLICATIONS

We examine the determinants of Kuwait's demand for electricity using aggregate data from 1972 to 2017. Initially, we utilize Augmented Dickey-Fuller (ADF), Dickey-Fuller GLS, and Phillips-Perron tests to explore the properties of our time series variables- electricity consumption, GDP, and price of electricity. Our results reveal that all the variables are non-stationary. Therefore, we implement Johansen cointegration test and find that there exists a cointegrating relationship between our variables. Consequently, we employ error correction models. We find that income is inelastic both in short and the long-run. Hence, we conclude that electricity consumers consider electricity as a necessity both in short and long-run. Besides, short-run price elasticity is estimated to be −0.22, while the long-run price elasticity is −1.22, indicating a negative yet elastic relationship between the electricity price in Kuwait and the demand in the long-run, while the short-run is inelastic. The findings of our analysis suggested that the demand for electricity in Kuwait depends mostly on price rather than income. This result can be explained by the fact that electricity prices in Kuwait are still low, approximately $0.07 per kWh, and the provided real prices in our analysis have captured the expected effect perfectly.

Energy prices in Kuwait are among the lowest around the world, while the consumption per capita is among the highest. We believe that the electricity pricing system in Kuwait is one of the primary

Table 7: Long-run results of error correction model

Dependent variable: *Electricity consumption*$_t$		
	Coefficient	Probability
GDP_t	−0.051	0.666
$Price_t$	−1.216	0.000
R^2	0.73	
Observations	45	

This table reports the long-run results of the error correction model

reasons behind the tendency toward electricity waste through overuse in Kuwait. Examples of this trend include the tendencies to keep excessive lights on throughout the night and leave the air conditioning running throughout the summer, even during vacation times (Eltony and Hoque, 1996).

We anticipate that Kuwait will soon require addressing the need for policy reform in terms of energy prices. Therefore, we believe that correctly estimating the price and income elasticities and the magnitude of the relationship between electricity consumption and its determinants could be critical and valuable to policy recommendations.

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