The Determinants of Demand for Electricity The Case of Jordan (1979-2008)

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1. Introduction

The importance of this study comes from the reason that electricity bill reflect a notable share in the GDP for Jordan, which reached 3.6% in 2008, also the prices of oil have went up very high during the period (2003-2008) because of the war between the NATO and Iraq, where oil is considered a medium good in the process of producing electricity, therefore the increase in the oil prices has affected on the prices of electricity positively.

This study is distinguished from previous literature in using recent data for Jordan until the year 2008 compared with until the year 2002 for the previous literature, this period between 2003 and 2008 have been distinguished with a large increase in the prices of oil, which reflected on the prices of electricity as we mentioned earlier.

The aim of this study is to investigate the main determinants of demand for electricity in Jordan during the period (1979-2008). For this purpose, an econometric model was built including four variables which are; Total consumption of electricity, real GDP per capita, real price of electricity and efficiency.

The study has used Breusch-Godfrey Serial Correlation LM Test to check for serial correlation between variables, and also it used Philips perron test to examine the stationarity of the variables, in addition to least squares analysis to examine the relationships between variables, and finally it used the Ramsey RESET test to check for the stability of the model.

This study is divided in to 6 sections: section 1 introduction, section 2 literature background, section 3 summary of electricity outlook in Jordan, section 4 the model, section 5 estimation results and discussions and finally section 6 conclusion.

2. Literature Background

Thomas and Mackerron (1982) examined the determinants of industrial electricity demand in the UK. They found that more than 40 percent (40%) of demand growth in the period (1959-1980) was due to factors either unrelated or only indirectly related to growth in industrial output. Factors such as adjustments in industrial structure, technical change and the decline in self-generation of electricity were all important contributors to demand growth. Together with the methodological problems of using price as an explanatory variable, the study suggests that those econometric approaches to demand forecasting for industrial electricity which rely solely on projections of industrial output and price are seriously defective. The study claimed that the level of output and price do affect the future demand, but current

methods are not appropriate to capture such effect. More detailed work on a sector basis is required and the structural and technical changes and developments in self-generation should be taken into consideration.

Holtedahl and Joutz (2000) examined the residential demand for electricity in Taiwan as a function of household disposable income, population growth, the price of electricity and the degree of urbanization. Short and long-term effects were separated through the use of an error correction model. In the long run, the income elasticity is unitary elastic. The own-price effect is negative and inelastic. In an error correction framework, the short run income and price effects were small and less than the long-run effects. The paper used a proxy variable, urbanization, to capture economic development characteristics and electricity-using capital stocks that were not explained by income. The variable provides significant explanatory power to the model both in the short- and long-run.

Chang & Chombo (2003) specified and estimated a double-log functional form of the demand equation, using monthly Mexican electricity data for residential, commercial and industrial sectors. Income, prices and a nonparametric temperature measure were used as explanatory variables, and the income elasticity was allowed to evolve slowly over time by employing the Time Varying Coefficient (TVC) co-integrating model. The specification of the proposed TVC co-integrating model was justified by testing it against the spurious regression and the usual Fixed Coefficient (FC) co-integrating regression. The estimated coefficients suggest that the income elasticity has followed a predominantly increasing path for all sectors during the entire sample period, and that electricity prices do not significantly affect the residential and commercial demand for electricity in the long run in Mexico.

Lin (2003) used a macroeconomic approach to develop a long-run electricity demand model to analyze the main determinants of electricity demand in the Republic of China (PRC). He found that the relationship among variables is more stable and significant after the PRC's economic reforms (1978), when all factors were more responsive to market forces. The paper included an error correction model that provided an appropriate framework for forecasting the short-run fluctuations in aggregate electricity demand. The study estimated demand elasticity of Gross Domestic Product (GDP) at about 0.8 after the 1978 economic reforms, lower than that of the pre-reform period (before 1978). The study results showed that although GDP is still the most important determinant of electricity demand, electricity demand is positively related to population growth and it is negatively related to structural changes, electricity prices and efficiency improvement. This implies that in a fast growing economy such as in the PRC, high GDP growth does not always come with high electricity demand.

Louw & others (2008) examined two typical low-income rural sites in South Africa, Antioch and Garagapola, where the Electricity Basic Services Support Tariff (EBSST) was piloted in 2002. The paper attempted to assess which factors affected the decision-making process for electricity consumption within these households. A log linear regression model was used. It was found that income, iron ownership and credit obtained positively significantly affect the consumption levels within these households. While wood fuel usage has a negative significant effect. Price and cross-price elasticity were difficult to assess due to lack of data within the sample. The results of their study have many possible implications for policy, including the effect that easily obtained credit has for low-income households.

Also Al-Azzam, (2002) wrote a dissertation about the demand for energy in Jordan which included demand for total energy, demand for electricity, demand for refined petroleum products and forecasting the demand for energy. Error correction model, ARDL analysis, Johnson test and Stock Watson dynamic OLS methodology were used in the analysis. He found that economic growth is likely to be accompanied by proportional increases in electricity demand while prices have a neutral impact on electricity consumption

Al-Majali, (2004) estimated the demand function for electrical energy in Jordan and its elasticities during the period (1975-2002) and investigated the determinants of the demand for the electrical energy in Jordan. Johanson, Durbin Watson and Engle & Granger cointegration tests were used in addition to Error Correction Mechanism and VAR vector auto-regressive model. He found significant negative relation between electricity price and electricity per capita consumption for the household sector, also he found significant positive relation between industrial sector product and electricity per capita consumption for the industrial sector.

3. Electricity Sector Outlook in Jordan

Due to its role in households' and producers' behaviors, electricity is considered a necessary good. Thus, price elasticity of demand is low especially in the time where no close substitute is available; the electric system in Jordan is serving about 99.9% of the population according to AL-Majali (2004) paper.

Electricity consumption grew notably during the period (1979-2008) where the average annual growth rate during this period was 53.1 percent compared to an average of 18.6 percent during the period (1998-2008). In 2008, the greatest consumption came from the household sector that consumed about 38.7% of total followed by producers sector which consumed 27.2% of total then commercial sector with consumption share of 16.7% followed by water pumping sector that consumed 14.9% then by street lighting sector which consumed 2.5%.

Looking at electricity demand related indicators we found that Real GDP per capita has increased by an average of 4.3% during the period (1979-2008) while fuels and electricity prices has increased by an average of 18.4% during that period. Through sectors, consumption of electricity for producers sector grew by an average of 45.7% during the period while the household sector consumption grew notably by an average of 52.5% during the same period.

In late year 2007 and the year 2008 several privatization operations were implemented in the electricity sector which resulted in partial privatization for the sector. In 2008 the price index of imports for mineral fuels and lubricants category increased by 31.7% due to the increase in the prices of oil while the CPI price index for Fuel and electricity category has increased by 48.5% which means that the privatization of electricity sector process has resulted in a notable increase in the prices of electricity.

In theory, consumption of electricity is considered a dependent variable of other related independent variables such as GDP per capita that affects the consumption of electricity variable positively, in addition to the Price of electricity variable that affects the consumption of electricity variable negatively.

In this paper, we will examine these relationships and try to relate them to the theory literature through an econometric model that will show results about Jordan as the case study country using data for the period (1979-2008). Table (1) shows the data of the model.

Table (1)
Model data

Year	EC (GWH)	(JD)GDP	EP	EF
1979	723	1188.3	27.7	1.4
1980	877	1262	34.5	1.2
1981	1028	1424	38.5	1.5
1982	1274	1467.1	41.5	1.1
1983	1623	1381.2	42.6	0.7
1984	1944	1386.7	42.8	0.7
1985	2151	1298.7	44.4	0.6
1986	2323	1318.9	43.1	2.8
1987	2655	1299.1	42.2	2.6
1988	2761	1268.8	42.3	2.2

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1989	2910	1090.6	43.5	2
1990	3089	986	45.5	1.9
1991	3141	938.7	49.4	1.6
1992	3674	1033.5	50.9	1.6
1993	3981	1039.6	54	1.3
1994	4330	1052.8	55.7	1.4
1995	4778	1091.4	55.7	1.4
1996	5122	1086	57.3	1.1
1997	5281	1094.3	59.2	1.2
1998	5634	1100.1	59.8	1.1
1999	5810	1108.3	59.9	1
2000	6133	1124.2	59.9	1
2001	6392	1154.7	61.9	1
2002	6906	1190.2	67.2	1.1
2003	7330	1208.9	72	1.1
2004	8089	1281.7	73.8	1.2
2005	8712	1348.2	80.4	1.1
2006	9593	1422.7	100	1.1
2007	10553	1483.7	102.9	1
2008	11509	1532.9	152.8	1.1

Where EC; is Total Electricity Consumption, GDP; is GDP per capita, EP; is Fuels and electricity price index and EF; is efficiency which is equal to size of industrial sector product divided by size of electricity consumption by industrial sector.

4. The Model

Our study aims at analyzing the effect of electricity demand determinants in Jordan. The study has a dependent variable and three independent variables, the dependent variable is: electricity consumption represented as LEC, the independent variables are: efficiency, real electricity price which is the CPI for Fuel & Electricity and real GDP per capita which are represented as LEF, LEP and LGDP respectively. Logs were taken to all variables, first difference was taken to the consumption of electricity and efficiency variables in order to find the best outcome of significant relationships that match the economic theory between variables of the study. The study model structure can be represented by the following equation:

$$DLEC_t = C + \beta_1 DLEF_t + \beta_2 LEP_t \; B3\, LGDP_t + \varepsilon_t \qquad 4.1$$

where C; is constant, $DLEC_t$; is the first difference taken for electricity consumption variable, $DLEF_t$; is the first difference taken for efficiency variable which

is equal to size of industrial sector product divided by size of electricity consumption by industrial sector. LEP_t, is CPI for fuel & electricity (proxy for real electricity price), $LGDP_t$, refers to real GDP per capita. while. $\beta_1, \beta_2, \beta_{3;\ are}$ *parameters,* ε_t*; is error term.*

5. Estimation Results and Discussions

5.1 Unit Roots Tests

To test for the presence of stochastic non stationary in the data used in this study, it is necessary to investigate the order of integration of the individual time series before any other tests. For this purpose standard unit root Philips-Perron (PP) test (Philips-Perron,1988) is conducted.

Philips and Perron (1988) propose a nonparametric method of controlling for higher-order serial correlation in a series. The test regression for the Philips-Perron test is the AR(1) process:

$$\Delta y_t = \alpha + \beta y_{t-1} + \varepsilon t \qquad (5.1.1)$$

PP test makes a correction to the t-statistic of the ã coefficient from AR(1) regression to account for the serial correlation in å. The correction is nonparametric since we use an estimate of the spectrum of å at frequency zero that is robust to heteroskedasticity and autocorrelation of unknown form. We use the Newey-West heteroskedasticity autocorrelation consistent estimate.

$$W^2 = \gamma^o + 2 \sum q_{v=1} (1-v/q+1)\, \gamma j \qquad (5.1.2)$$

$$\gamma j = (\sum^T_{t=j+1} \varepsilon t\, \varepsilon t\text{-}j)/T \qquad (5.1.3)$$

and q is the truncation lag. The PP t-statistic is computed a

$$t_{pp} = \gamma^o 1/2 t_{b/w} - (w^2 - \gamma^o) T s_{b/2ws} \qquad (5.1.4)$$

where ^{t}b, ^{s}b are the t statistic and standard error of â and s is the standard error of the test regression. The results of the test using the first difference of the logarithms suggest that the individual series are stationary. In summary, we accept that in log levels, the LEC, LEF, LEP and LGDP have a single unit root or are integrated of degree one *I*(1) as shown in table(2):

Table (2)
Philips-Perron Test Results

Philips-Perron Test results Variable	Critical value	Calculated value (10%)
LEC level	-2.6	-4.5
LEF level	-2.6	-2.7
LEP level	-2.6	1.4

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LGDP level	-2.6	-0.4
ÄLEC	-2.6	-2.8
ÄLEF	-2.6	-5.7
Ä LEP	-2.6	-2.7
Ä LGDP	-2.6	-3.2

5.2 Least Squares Test Results

Using matrix notation, the standard regression may be written as:

$$y = X\beta + \varepsilon \qquad 5.2.1$$

where *y is a T- dimensional vector containing observations on the dependent variable, X is a T*K matrix of independent variables, â* is a *k*- vector of coefficients, and *å* is a *T*- vector of disturbances. *T* is the number of observations and *k* is the number of right hand side regressors.

Least square method was used to estimate the model data through the period (1979-2008) for Jordan as the case study country.

$$DLEC_t = C + \beta_1 DLEF_t + \beta_2 LEP_t \; B_3 LGDP_t + \varepsilon_t \qquad 5.2.2$$

$$DLEC_t = -1.63 - 0.04DLEF_t - 0.09\, LEP_t + 0.29\, LGDP_t + \varepsilon_t \qquad 5.2.3$$

t-statistic: [-4.41][-3.14] [-4.61] [+5.13]

It was found that Durbin-Watson value of 1.59 which is greater than DW table value upper limit. This means that there is no evidence of serial correlation, (R square 0.589, F-statistic 11.9 and is statistically significant, all coefficients were found statistically significant as t statistic value was found greater than the absolute value of 2 for all variables. The econometric relationships were as follows:. It was found that real GDP per capita variable significantly positively affect the demand for electricity. Alternatively, real price of electricity and efficiency variables were found to have a significant negative effect on the consumption of electricity. All the relationship results were found logical in terms of theory.

5.3 Breusch-Godfrey Serial Correlation LM Test

This test is used to check for serial correlation between variables of the Model, the results show that there is no serial correlation between study variables as the probabilities were less than 0.6 as shown in table (3):.

Table (3)
Breusch-Godfrey Serial Correlation LM Test

F statistic: 0.933	Probability: 0.34
Obs *R-squared: 1.085	Probability: 0.30

5.4 Ramsey RESET Test for Model Stability

This test is used to check for stability of the model, according to the data results, the model is stable because F statistic & Log likelihood ratio were significant as shown in table (4):

Table (4)
Ramsey RESET Test

F statistic: 5.89	Probability: 0.023
Log likelihood ratio: 6.37	Probability: 0.012

6. Conclusion

In this paper, a model has been built, it included the consumption of electricity as the dependent variable on the one hand, and efficiency, real electricity price and real GDP per capita as the independent variables on the other hand. Jordan is the case study country in this paper, the data cover the period (1979-2008), relationships between study variables were examined.

The relationship between efficiency and consumption of electricity was found significant and negative, Lin (2003) found similar results. In addition, the relation between real price of electricity and electricity consumption was found to be significant and negative. Thomas & Mackerron (1982) found similar results, also the relationship between electricity consumption and real GDP per capita was found to be significant and positive, this can be explained by the continuous economic growth that was achieved in the kingdom that resulted from large economic investment projects which consumed large quantities of electricity. Thomas & Mackerron (1982), Lin (2003), Al-Azzam (2002) and Louw & others (2008) found similar results. All the relationship results were found logical in terms of economic theory.

The results of this study may have implications for policy makers who should focus on macroeconomic factors such as GDP per capita, price of electricity and efficiency to be the main factor affecting the demand for electricity.

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