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Determinants of Electricity Demand in Jordan

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Abstract

Electricity is the most known form of energy that is related to production and crucial determinant of economic growth. This paper aims at identifying the determinants of electricity demand in Jordan. To achieve that goal the study employs an economic model that includes the following explanatory variables: Real GDP growth rate, population growth, the domestic energy price index and improvement in production efficiency in the manufacturing sector. This approach will be carried out using the Auto Regressive Distribution Lags (ARDL) model in order to find the determinants of electricity demand in Jordan. The findings of the study came to be consistent with the economic theory by showing that the demand for electricity grows directly and significantly with the growth of the real GDP and population. Means as the population of the country grows at rapid rates, policy makers should be prepared to make the necessary actions to face larger electricity demand in the future. Interestingly, the results show that a higher level of domestic inflation gives incentives to people to save on the electricity consumption. Finally, as expected, the results show that with an improvement in the performance of the manufacturing sector, demand on electricity goes down. Based on these results, the government should facilitate all procedures for economic units to adapt advanced means of production and consumption of energy to meet the increasing electricity demand.

Keywords: ARDL Model, Efficient Energy, Electricity Demand, Jordan

1. Introduction

One of the major goals of consuming energy is to make economic, social and environmental development more sustainable. This goal should be related to the goal of replacing unsustainable resources of energy with sustainable and continuous resources since economic sectors depend heavily on energy consuming. However, consuming energy should be used wisely since some resources like oil is a depleting one. Some countries (like oil-producing countries) are over consuming since they provide oil and its derivatives to their citizens with prices that are lower than their real costs.

Energy is directly related to major social issues that affect sustainable development, such as poverty, unemployment, income levels and chances to receive social services. The issue of the lack of availability of relatively cheap energy and the regulation of the energy market are two of the most pressing issues in the Jordanian economy. These issues need to be addressed, since the Jordanian economy depends on the importation of all types of energy, including oil and natural gas. The issues continue to be important because of the change in the oil price in the international market. This change may cause economic shocks, since it has negative effects on production, aggregate demand, poverty levels and unemployment in Jordan. The expected increase in oil prices in the future and the lack of a clear energy strategy that can provide alternatives to deal with the issue, such as building a strategic stock of oil and natural gas, leave Jordan unprepared to face any crises in the international oil market and spare the national economy any unexpected shocks.

Countries that face sharp increases in oil prices try to find alternative energy resources. For example, Jordan is a country that produces electricity mainly using fuel oil that covers its domestic consumption. But when crude oil prices witness huge fluctuations and especially during times of high oil prices, this forces Jordan to foster the

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process of utilizing other fuel oil alternatives like shale oil and nuclear power. Other countries like Lebanon, because of high oil prices, try to produce electricity using other means like wind and sun energy.

In Jordan, some manufacturing industries, as well as households, use electricity instead of oil products for production, heating and other uses. However, the electricity price increased significantly in the last few years. Despite this continuing and noticeable increase in the price, electricity is still cheaper for households and production sectors than other sources of energy, which means an increase in electricity demand in the future.

Two of the most important issues facing the Jordanian economy are the sharp fluctuations in the international energy market and its effect on the cost of production and the price of electricity. The importance of this study stems from the fact that studying the demand on electricity will help to determine the sources and the loads needed in the future. This research will also examine the effect of the electricity demand on economic growth and the standards of living of the Jordanian people directly. Most studies on electricity demands focus on the Gross Domestic Product (GDP), price of electricity and the geographic area of the country. Therefore, this study attempts to fill the gap in the literature by including more variables that may affect the demand on electricity in Jordan. Based on that, this study's main goal is to analyze the demand for electricity in the Jordanian economy during the period 1985-2006 and understand its determinants.

In Jordanian context, there aren't that many studies that deal with the issue of electricity demand and most of those are primarily descriptive in nature. In[1] using an econometric model to estimate the energy demand in the Jordanian economy for the period 1968-1997, the Stock-Watson Dynamic OLS (DOLS) approach was used to estimate the elasticity of energy demand in Jordan. It was found that the elasticity of energy demand with respect to income is almost unitary and there was a time lag in the demand response to the change in price.

In Lebanon, it was shown the relationship between the consumption of electricity and climate factors using co-integration analysis and the Error Correction Model (ECM) for the periods 1992-1996 and 1997-1999. It was found that in the second period that there was a significant effect of temperature on the consumption of electricity in the summer, while that was not the case in the winter[2]. An econometric model was developed using co-integration analysis, to study the electricity demand in China[3]. It was found that there is a long-run relationship between the consumption of electricity and some explanatory variables like GDP, price of electricity and population. The relationship was found to be statistically significant, particularly after the start of the economic reform period in 1978.

In India[4], it was found that higher income and middle income people have preference over energy efficient electrical appliance but majority of the poor people uses the energy in efficient household products, due to high cost of energy efficient appliances.

In Jordan[5], it was estimated the long-run elasticity of energy demand for consumption purposes, not just electricity, for the period 1980-1999 using the DOLS technique. The results reveal that income elasticity of final consumption is 1.15, implying that economic growth is directly related to the consumption of energy. However, the price elasticity was found to be (-1.14). The determinants of renewable energy consumption per capita for seven Central American countries were examined over the period 1980 to 2010. The results found a long-run co-integrated relationship exists between renewable energy consumption per capita, real GDP per capita, carbon emissions per capita, real coal prices and real oil prices with the respective coefficients. The results of the non-linear panel smooth transition vector error correction model show that for the post-2002 period, the influence of renewable energy consumption per capita upon real coal and oil prices strengthened relative to the pre-2002 period[6].

The rest of the paper is arranged in the following manner. Section 2 looks into the nature of the electricity market in Jordan. Section 3 explores the sources of the data and discusses the methodology used in the study. While Section 4 gives the analysis of the results, Section 5 provides the conclusion and puts forward some suggestions about future research.

2. The Nature of the Energy Sector in Jordan

The Government of Jordan makes tireless efforts for the search and exploration of alternative energy sources within the boundaries of the country, which cost the state's treasury a sizable amount of money. The result of these searches concluded that there are huge quantities of shale oil that exist and are believed to be economically viable to be excavated for commercial purposes. This oil could be used in direct burning for electricity generation or to produce crude oil, especially with the technological developments worldwide that meet the environmental requirements in Jordan. Finding this shale is very important given that the domestic commercial production of energy resources is only around 4% of all annual required amounts of primary energy sources, according to the Jordanian Ministry of Energy and Mineral Resources (Annual report, 2011). Jordan, therefore, depends almost completely on the importation of crude oil, natural gas and oil products to cover its energy needs.

Table 1 shows Jordan's importation of crude oil and oil products for the period 2003-2009. Crude oil is imported via the port of Aqaba and transported to the Jordanian Refinery and consumption centers by trucks. Natural gas is imported from Egypt though the Arab Gas Pipeline. The volume of natural gas importation during the period 2006-2009 was 7.89, 35.7, 45.7 and 72 billion cubic feet, respectively (Ministry of Energy and Natural Resources, Annual Report, 2011).

The consumption of primary energy resources grew by an annual rate of 5.4% during the period 2003-2009 and is in line with the 6.5% growth rate of GDP during the same period (Department of Statistics Annual Report, 2011). Table 2 below shows the demand for the primary energy resources during the period 2003-2009.

The consumption of oil products can be seen in Table 3. The demand for fuel oil declined starting in 2006 because of the switch to natural gas instead to generate electricity. Also the demand for diesel declined, while the demand for natural gas increased, indicating a change in the pattern of household and commercial energy consumption.

Table 1. Imports of crude oil and petroleum products (2003-2009) (Thousand metric ton)

Year	Crude Oil	Fuel Oil	Liquefied Gas	Diesel	Gasoline	Jet fuel
2003	3778	626	133	239	–	–
2004	3875	647	138	182	–	–
2005	3926	785	155	230	25	–
2006	4023	570	171	292	40	5.5
2007	4244	100	179	543	135	1.1
2008	4600	19	178	785	93	1
2009	4258	–	182	509	65	1

Source: Ministry of Energy and Natural Resources, Annual Report, 2011.

Table 2. The consumption of primary energy (2003-2009) (Thousand metric tons)

Year	Types of Primary Energy				
	Crude Oil and Oil Derivatives	Natural Gas	Renewable Energy	Imported Electricity	Consumable Primary Energy
2003	4815	213	75	11	5114
2004	4803	206	76	65	5150
2005	4954	188	79	78	5299
2006	5030	432	77	234	5774
2007	5012	1196	82	199	6489
2008	5325	1384	83	238	7028
2009	4953	1820	111	124	7187

Source: Ministry of Energy and Natural Resources, Annual Report, 2011.

Table 3. The development of consumption of oil derivatives (2003-2009) (Thousand metric tons)

Year	Liquefied Gas	Gasoline	Jet Fuel	Kerosene	Diesel	Oil Fuel	Asphalt
2003	283	596	243	242	1202	1957	112
2004	276	640	175	185	1274	2001	135
2005	292	655	178	174	1417	2133	175
2006	298	668	215	214	1439	1967	204
2007	290	670	228	215	1769	1509	210
2008	299	697	314	181	2005	1395	192
2009	313	741	300	150	1837	1333	200

Source: Ministry of Energy and Natural Resources, Annual Report, 2011.

Gas consumption increased by an annual rate of more than 4% during the same period. Also diesel consumption grew by about 8% because of the growth of the transportation sector; it consumes about 37% of the total final energy resources.

The consumption of electricity grew by higher rates than the consumption of primary energy sources because of the expansion of the use of electricity by commercial and household sectors. The national electricity transportation grid was expanded to cover the entire country. Ninety-nine percent of the people in the country are electricity customers, up from only 67% in 1975. The compounded production capacity of electricity in Jordan, as of April 2009, was 2120 Megawatts, while the maximum load was 1860 Megawatts (Ministry of Energy and Natural Resources, Annual Report, 2011). The growth rate of electricity consumption for the period 2003-2009 was about 7.4%, which is considered a high rate of electricity consumption in developing countries. The electricity consumption is about 85% of the total electricity produced and this rate is expected to grow more with the continuing development in the transportation grid and distribution system.

Table 4 shows the development in the consumption and distribution of electricity among different sectors in the Jordanian economy. The household sector consumes the largest percentage, 34%, followed by the manufacturing sector, 31% and then the water pumping sector at 15%.

Based on the population estimations done by the Department of Statistics, the per capita energy consumption increased from 1015 kg oil equivalent in 2003 to 1281 kg oil equivalent in 2009, with an annual growth rate of 2.6%. The per capita electricity consumption for the same period increased from 1218 kwh to 1586 kwh, with a growth rate of 3.02%.

3. Data and Methodology

This study depends on the published and unpublished data of the Central Bank of Jordan, Department of Statistics, Ministry of Energy and Mineral Resources and the Electricity Regulation Authority. This research also uses the calculated rate of efficiency improvement in the manufacturing sector.

This paper uses a special model to estimate the electricity demand after checking for stationarity in the data. The study uses the following model:

$$EC_t = \alpha_0 + \alpha_1 RGDP_t + \alpha_2 POP_t + \alpha_3 P_t + \alpha_4 EFF_t + U_t \quad (1)$$

Where EC_t represents the growth rate of electricity demand; $RGDP_t$ represents the growth rate of the real GDP; and POP_t represents the population growth rates. P_t represents the energy price growth rate; EFF_t represents the growth rate of efficiency improvements in the manufacturing sector; and U_t represents random errors.

The model includes the real GDP, because it is considered to be the main determinant of the electricity demand growth rate. The economic growth rate clearly affects the standard of living of the population, thus affecting the demand for electricity. Previous studies[7,8] show that there is a positive relationship between real GDP growth rate and electricity demand growth rate.

The growth rate of energy prices is another important determinant of electricity demand. In this study, we use a compound variable to represent this determinant. That variable is the energy price index that includes prices of electricity and oil products. Oil products affect the electricity generation and determine the cost of electricity, because oil products are the major input in electricity generation. We expect a negative relationship between the electricity demand growth rate and the growth rate in the energy prices.

Population growth rate is considered a determinant of electricity demand, since higher population leads to higher electricity consumption[3]. Therefore a positive relationship between the electricity demand growth rate and population is expected.

Finally, efficiency improvement in the manufacturing sector is used as a determinant of electricity demand. This variable is used since the continual maintenance and improvements in manufacturing process lead to a

Table 4. Sectoral distribution of electric energy consumption (2003-2009) (Giga Watt Hour - GWH)

Year	Household Sector	Industrial Sector	Commercial Sector	Pumping Water	Lighting Streets	Other	Total	Growth Rate
2003	1981	1974	805	990	173	210	6133	5.6 %
2004	2110	2024	880	982	177	219	6392	4.2 %
2005	2266	2193	971	1044	190	236	6900	7.9 %
2006	2471	2310	1047	1104	201	213	7346	6.5 %
2007	2745	2479	1190	1261	213	201	8089	10 %
2008	2975	2659	1317	1298	248	201	8698	7.5 %
2009	3421	2757	1516	1396	261	228	9579	10.1 %

Source: Ministry of Energy and Natural Resources, Annual Report, 2011.

decrease in electricity consumption per production unit. The rate of efficiency improvement in the manufacturing sector is measured by dividing the additional volume of the manufacturing sector by the amount of electricity consumed by it. Here and as found[9], we expect an inverse relationship between the electricity demand growth rate and the efficiency improvement growth rate.

3.1 Time Series Stationarity Test

Non-stationarity is considered a major problem in dealing with time series data. Most time series economic data suffers from this problem, since the mean and the variance change over time. Therefore, the OLS technique will result in biased coefficients[10]. This means that we may obtain high values of t-statistics, f-statistics and R^2 values, indicating significant values of the coefficients that do not actually exist and would lead to spurious conclusions[11].

To insure the stationarity of the data, we apply the Augmented Dickey-Fuller (ADF) test. To do this, we estimate the following relationship:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \rho Y_{t-1} + \sum_{j=2}^{q} \alpha_j \Delta Y_{t-j+1} + \varepsilon_t \qquad (2)$$

Where Y_t represents the variable that we want to test[12].

The ADF uses the null hypothesis H_0: $\rho = 1$, the alternative hypothesis H_1: $\rho < 1$ and comparison of the calculated value of (τ) with the value from Mackinon table. If the calculated value is greater than the critical value, then the null hypothesis is rejected and the time series is considered stationarity of degree zero. Therefore, we can use the OLS technique. However, if the calculated (τ) is lower than the critical value, we cannot reject the null hypothesis and the time series is considered non-stationarity. In order to determine the degree at which the time series reaches stationarity, we repeat the test after taking the first difference and check for stationarity. If the time series appears to be stationarity, then the data is called integrated at first degree I (1). If not, then the tests are repeated with the second difference taken and so on, up to (d) tests.

3.2 The Estimation Process using ARDL

The paper uses the Auto Regressive Distributed Lag (ARDL) technique to estimate the model. We can use this technique to determine the co-integration relationship of the dependent variable with the determinants both in the short and long run. Also we can use it to determine the size of the effect of each determinant on the dependent variable[13]. For example, if we want to measure the effect of X on Y, we can use Equation 3:

$$\Delta Y_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 Y_{t-1} + \sum_{J=0}^{k1} \beta \Delta X_{t-J} + \sum_{j=1}^{k2} \beta_2 \Delta Y_{t-J} + e_t \qquad (3)$$

One characteristic of the ARDL is that it does not require the same level of stationarity in the variables. We use this technique, since the variables in our model have different levels of stationarity. Also, the ARDL technique depends on the Schwarz-Bayesian Criteria (SBC) that is used to determine the optimal lags. In addition, the ARDL gives the results of the Error Correction Model (ECM), which measures the ability of the model to go to equilibrium after the occurrence of some disturbances[14]. The ARDL technique also removes the problems associated with the autocorrelation issue. Therefore, the results that come from using ARDL are considered efficient and unbiased[15].

4. Empirical Results

This study estimated the electricity demand in Jordan. Before doing so, we performed the ADF test on all of the variables in the model to test for their stationarity. Table 5 shows the results of the ADF test, clearly showing that all the variables were not I (0) at the 5% significance level. Using the first difference, some of the variables appeared to be I (1). However, the rest of the variables were I (2). To insure the validity of the ADF test, we performed the PP test. This test, developed by[16], uses a nonparametric approach to test for a unit root in the time series. The results of this test are shown in Table 5. The PP test results insured the ADF test results indicating that the variables in the model were stationarity at different levels. This means that we cannot perform the co-integration test that requires the same level of stationarity[10]. In that regard, we can see the necessity of the use of the ARDL technique, which does not require the same level of stationarity[17].

The results of the preliminary diagnostic statistics to test the fitness of the model showed that the model is well defined. The tests showed no econometric problems that might affect the efficiency or the biasedness of the results. Table 6 shows that the model met all the requirements of fit. The x^2 test did not show any serial autocorrelation in the residuals and no heteroskedasticity. Also, the RESET test[18] showed no signs of misspecification of the model. The ARDL results show the ECM (-1) with a

Table 5. ADF and PP tests results

The variable	ADF Test			PP test		
	Calculated value	Critical value	Stationarity level	Calculated value	Critical value	Stationarity level
EC	−4.551	−3.674	I(1)	−4.550	−3.674	I(1)
RGDP	−4.689	−3.691	I(0)	−3.665	−3.674	I(1)
POP	−44.116	−3.733	I(0)	−7.676	−3.691	I(2)
P	−3.334	−3.711	I(2)	−4.541	−3.6908	I(2)
EFF	−7.713	−3.277	I(1)	−7.713	−3.674	I(1)

*The test equation includes intercept and time trend.

Table 6. The results for estimating the model using ARDL

Variable	coefficient	Std. Error	t-ratio	Probability
RGDP	0.856	0.27	8.44	0.00
POP	0.25	0.078	3.23	0.012
P	−0.033	0.08	−3.61	0.007
EFF	−0.78	0.043	−17.9	0.00
ECM(−1)	−0.248	–	−3.54	0.0035
R-squared	0.97			
DW	2.79			
Diagnostic Tests:			F-test	Probability
Serial Correlation			3.03	0.125
RESET			0.678	0.437
Heteroscedasticity			0.322	0.577

negative value less than one, which indicates a long-run relationship among the variables. These results indicate that the model is stationarity and that there is a long-run relationship among the variables.

The results of the ARDL technique are shown in Table 6. The results of the economic model appear to be in alignment with the economic theory. In particular, the increase in the real GDP by 1% will lead to a 0.856% increase in the demand of electricity and population growth by 1% leads to an increase in demand by 0.25%. As the population of Jordan grows faster than those of many other countries, the results of the study indicate that the policy makers in Jordan should be prepared to make the changes necessary to face larger electricity demand in the future.

The effect of the price index is negative and minimal in effect. An increase in the energy price index by 1% causes a decrease of 0.033% in the electricity demand. This result indicates that a higher level of domestic inflation gives incentives to people to save on the electricity consumption. Finally, the results show that with an improvement in the performance of the manufacturing sector, demand on electricity goes down. Specifically, the effect of the efficiency improvement in the manufacturing sector was relatively large with an effect of -0.78%. Based on the results of the study, the authors recommend that in order to reduce the demand for electricity in Jordan, the policy makers, especially the government, should facilitate all procedures to encourage the economic actors in Jordan to adapt new means of production and consumption of energy to meet the increasing future demand of electricity.

5. Conclusion and Recommendations

This paper analyzed the energy sector in Jordan during the period 1985-2006. Specifically, we researched the demand for electricity using the real GDP, population, energy price index and efficiency improvement in the manufacturing sector as determinants of electricity consumption. Using the ARDL technique, the study showed that the growth of the real GDP and population caused higher demand for electricity. On the hand, the energy price index and efficiency improvement in the manufacturing sector were negatively related to the demand.

Based on the results of the study, the authors recommend implementing policies that result in efficiency improvements in the consumption of electricity in addition to keep the search for development of alternatives to the traditional energy resources, such as natural gas and shale oil. These resources could be substituted for fuel oil and diesel in different industries and electricity generation in a first step. After that, the policies should be aimed at the use of the new sources for household, commercial and transportation use. The policies should focus on encouraging the private sector to invest in the energy sector, especially the electricity sector and building and operating its projects. Our final recommendation is to expand the electricity generation and oil refining facilities to meet the continued expansion of the demand in the energy sector.

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