Forecasting Household Electricity Consumption in Jordan

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Abstract: The study aims at forecasting household electricity consumption in Jordan using the data over the period of (1986 – 2009). A statistical package for social sciences (SPSS) program was used for descriptive analysis that includes, multiple linear regression, the use of logarithm function in estimation and forecasting, the use of (T) test and (F) test to know the significant effect of the independent variables population, GDP, prices of electric power on household electricity consumption, individually and collectively. The study reached a set of results and found out that there is a significant effect of both population and GDP on the amount of electricity consumed in the household sector. The paper provides some relevant recommendations to policy makers in the electric power sector such as setting educational programs and continues on price list categories to reduce and save electrical energy consumption in the household sector.

Keywords: Electricity · Consumption · Household · Energy · Forecasting

INTRODUCTION

The GDP growth, population growth and the electricity prices are the main driving factors that affect the electricity consumption. According to IMF report the expected GDP growth rates for the next ten years for the national economy is about 4.6% [1]. The electric energy sector is an important and vital sector among various productive and service sectors. It is considered the most prominent sector that contributes in the development of the national economy. The government of Jordan has played attention to the electrical energy sector as they believe it plays a major role in upgrading the standard of living and welfare of its citizens. The household sector is one of the largest sectors of electric power consumption, since the amount of electrical energy consumed for household equivalent to 36% of the total amount of electricity consumed in Jordan during the year (2009) and 99.9% of the population are served with electricity.

The electricity bill reflect a notable share in the GDP, which reached 3.6% in 2008, also in recent years crude oil witnessed a hike in prices after the war on Iraq. As Jordan depends on oil to produce electricity, the increase of oil prices has affected the prices of electricity [2].

According to the department of statistics about (17%) of households is using electricity for heating and about 46% of households are using electricity for cooling purposes (2008), [3]. As shown in Figure 1. There is a growing consumption of electricity by the household sector with notable upward trend.

Study Objectives: The research aims to measure and analyze factors affecting household electricity consumption and to forecast electricity consumption in the household sector for the next ten years using the data over the period of 1986-2009 shown in Table 1.

Study Importance: The importance of this study includes the following:

- Jordan imports oil from foreign countries and generating electricity depends on oil which imported from foreign countries at the time of rapid increase in oil prices. That means the cost of electricity is very high. Therefore, government attention to the electricity sector is required.

Previous Studies: There are many notable studies on the subject:

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Fig. 1: Household consumption of electricity in absolute terms (1986-2009).

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption (KWh)</th>
<th>Population (Thousands)</th>
<th>GDP (Thousands JD)</th>
<th>Electricity price (KWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>618</td>
<td>2805</td>
<td>3311</td>
<td>68</td>
</tr>
<tr>
<td>1987</td>
<td>650</td>
<td>2914</td>
<td>3376</td>
<td>68</td>
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<tr>
<td>1988</td>
<td>693</td>
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<td>3415</td>
<td>63</td>
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<td>1989</td>
<td>709</td>
<td>3144</td>
<td>3044</td>
<td>50</td>
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<tr>
<td>1990</td>
<td>757</td>
<td>3468</td>
<td>3013</td>
<td>43</td>
</tr>
<tr>
<td>1991</td>
<td>818</td>
<td>3701</td>
<td>3093</td>
<td>40</td>
</tr>
<tr>
<td>1992</td>
<td>944</td>
<td>3844</td>
<td>3442</td>
<td>38</td>
</tr>
<tr>
<td>1993</td>
<td>1042</td>
<td>3993</td>
<td>3584</td>
<td>36</td>
</tr>
<tr>
<td>1994</td>
<td>1161</td>
<td>4139</td>
<td>3765</td>
<td>35</td>
</tr>
<tr>
<td>1995</td>
<td>1265</td>
<td>4264</td>
<td>4032</td>
<td>34</td>
</tr>
<tr>
<td>1996</td>
<td>1385</td>
<td>4383</td>
<td>4109</td>
<td>32</td>
</tr>
<tr>
<td>1997</td>
<td>1442</td>
<td>4506</td>
<td>4255</td>
<td>27</td>
</tr>
<tr>
<td>1998</td>
<td>1588</td>
<td>4623</td>
<td>4409</td>
<td>26</td>
</tr>
<tr>
<td>1999</td>
<td>1630</td>
<td>4738</td>
<td>4535</td>
<td>26</td>
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<tr>
<td>2000</td>
<td>1762</td>
<td>4857</td>
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<td>26</td>
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<td>2001</td>
<td>1886</td>
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<tr>
<td>2008</td>
<td>3695</td>
<td>5852</td>
<td>8409</td>
<td>33</td>
</tr>
<tr>
<td>2009</td>
<td>4048</td>
<td>5980</td>
<td>8717</td>
<td>34</td>
</tr>
</tbody>
</table>

Sources (4, 5, 6)


In (1970), [12] develop a dynamic model in which the current level of the state variable is determined by the cumulative effects of past behavior and the change in the level of the next period's state variable is partly determined by current decisions. In (1974), [13] and in (1980), [14] used this approach to model residential electricity demand and estimate price elasticities at the national and regional levels. In (1973), [15] did a similar analysis estimating the electricity demand function on the household and industrial sectors in the United States by using two multiple regression models for annual data (1961-1971).

In (1981), [16] and (1987), [17] use the partial adjustment model with error components and a seemingly unrelated regressions (EC-SUR) procedure to estimate demand equations for electricity and other energy use. Both of these studies simultaneously estimate equations for multiple customer classes and energy sources at a regional, annual level. They find that EC-SUR achieves more efficiency than the OLS and error components approaches.

In (1989), [18] estimates the demand function of electricity for the household sector in Kuwait using three models for monthly time series data for the period (1977-1981). The study concluded that there is an inverse relationship between electricity consumption and both the price of electricity and average relative humidity, while there is a positive relationship between electricity...
consumption and both the average per capita income and average temperature. In (1994), [19] examine the trends of electricity in Kuwait and future electricity demand depending on time series data for the period (1986-1987) using linear regression model. Also in (1997), [20] uses the same model to estimate the annual electricity demand in the Saudi capital of Riyadh for the variables of average price of electricity, the average per capita income, the inflation rate and population.

In (2004), [21] study the demand for electricity for household and industrial sector in the U-S by using two models of regression for the annual data of (1973-1998). They argue that one difficulty in estimating electricity demand is the potential simultaneity between price and quantity. Because of this problem, some researchers have promoted simultaneous equation approaches over partial adjustment models. Also in (2009), [22] presented two techniques, for modeling electricity consumption of the Jordanian industrial sector one for Multivariate Linear regression and neuro-fuzzy models for different variables such as number of establishments, number of employees, electricity tariff, prevailing fuel prices and production outputs. The results showed that both the multivariate linear regression and neuro-fuzzy models are generally comparable and can be used adequately to simulate industrial electricity consumption.

In (2009), [23] analyses historical data of residential electricity demand in the United States for the period 1970-2007. Such analysis is conducted through an ADF unit root test, Johansen test and a rolling regression. The results indicate that the primary driver of adjustments in electricity consumption is the own price elasticity of demand and growth in real income per capita. Also in (2009), [24] re-investigates the electricity consumption function for Malaysia through the cointegration and causality analysis over the period 1970 to 2005. The study employed the bounds-testing procedure for cointegration to examine the potential long-run relationship, while an autoregressive distributed lag model is used to derive the short- and long-run coefficients. The Granger causality test is applied to determine the causality direction between electricity consumption and its determinants.

In (2010), [25] explore the role of economic and non-economic factors in the determination of household’s demand for electricity in the Pakistani district of Peshawar. Multinomial logistic model was used to derive estimates. The study concluded that income, number of rooms, price of electricity, weather and education are important determinants of household demand for electricity in the district.

In (2010), [26] investigate the presence of co-integration and causality relationships for energy consumption in the three largest Asian Association for Regional Cooperation countries, Bangladesh, India and Pakistan. They use Engle and Granger co-integration technique, Johansen's co-integration test, error correction model and Granger causality test. And in (2011), [27] and in (1962), [28] uses model to estimate the household electricity demand in Gambia from 1982 to 2007. He argues that an electricity demand should be estimated simultaneously with the supply. It then estimates the demand for and the supply of the electricity using reduced form regressions and vector error correction methods. He finds that systems of simultaneous equations cannot be simplified to reduced form regressions to satisfy the statistical requirements, but rather the theoretical modeling requirements determine the choice of the statistical model. The vector error correction method inline with theoretical restrictions of the model is found to better fit the data than the reduced form regressions. From the estimation results of this method, the electricity demand is found to be price elastic and income elastic.

Also in (2011), [29] examine the short-and long-run causal relationship between energy consumption and gross domestic product (GDP) of six emerging economies of Asia. The paper employs co-integration and vector error correction modeling along with generalized impulse response functions and variance decomposition tests to check the robustness of the findings.

**Hypotheses:**

**H01:** There is no significant effect of population on the amount of electricity consumed in the household sector at the level of significance (0.05).

**H02:** There is no significant effect of GDP on the amount of electricity consumed in the household sector at the level of significance (0.05).

**H03:** There is no significant effect of electricity prices on the amount of electricity consumed in the household sector at the level of significance (0.05).

**H04:** There is no significant effect of over all variables (population, GDP, prices of electricity) on the amount of electricity consumed in the household sector at the level of significance (0.05).
Methodology: In this paper, I will use the econometric approach for multiple regressions. (F) test and (T) test to determine the impact of independent variables population, gross domestic product (GDP) and electric energy prices on the household electricity consumption, depending on the data issued by the electricity companies, the Ministry of Planning and the Department of Statistics over the period of (1986-2009). I have tested several models to forecast the household electricity consumption and found that the most appropriate model which depends on the Mean square error (MSE) is the following logarithmic function

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + u \]  

(1)

Where:
Y: The amount of electricity consumed in the household sector (kwt)
X1: Population of the Hashemite Kingdom of Jordan (in thousands)
X2: GDP (in thousands of diners)
X3: Average prices of electricity (fils / kWh)
U: Random error

In order to estimate the parameters of \((\beta_0, \beta_1, \beta_2, \beta_3)\), it requires changing function (1) to linear function by taking the (Ln) of both sides of the equation as follows:

\[ \ln y = \ln (\beta_0) + \beta_1 \ln (X1) + \beta_2 \ln (X2) + \beta_3 \ln (X3) + u \]  

(2)

The use of dummy variable in this model and analysis is not possible despite the widespread use of air conditioners and the direction of many citizens in using solar energy due to limitation of available data during the study period.

Findings

Forecasting Equation: The forecasting equation for household electricity consumption could be written as follows:

\[ Y = 0.000078 + 1.086 \times \log (X1) + 0.984 \times \log (X2) - 0.100 \times \log (X3) + u \]

Hypotheses Testing:

Ho1: There is no significant effect of population on the amount of electricity consumed in the household sector at the level of significance (0.05).

Table 2 shows that p value (0.000) is less than the level of significance (0.05), \(\alpha \leq 0.05\).

| Ho2: There is no significant effect of GDP on the amount of electricity consumed in the household sector at the level of significance (0.05). |

Results obtained from Table 3 shows that the p value (0.000) is less than the level of significance (0.05).
Therefore we reject the null hypothesis and accept the alternative hypothesis which states that "there is significant effect of GDP on the amount of electricity consumed in the household sector at the level of significance (0.05)."

**Ho3:** There is no significant effect of electricity prices on the amount of electricity consumed in the household sector at the level of significance (0.05).

In Table 4 the p value (0.274) is greater than the level of significance (0.05).

Based on this result we accept the null hypothesis which states that "there is no significant effect of energy prices on the amount of electrical power consumed in the household sector at the level of significance (0.05)" and reject the alternative hypothesis.

**Ho4:** There is no significant effect of over all variables (population, GDP, prices of electricity) on the amount of electricity consumed in the household sector at the level of significance (0.05).

Based on the results obtained from table 5, the F value (0.00) is less than the level of significance (0.05).

So we reject the null hypothesis and accept the alternative hypothesis which states that "there is significant effect of all variables (population, GDP, prices of electric power) on the amount of electricity consumed in the household sector at the level of significance (0.05)."

The coefficient of \( R^2 \) has reached a value (0.998). This means that the explanatory variables (population, GDP, prices of electric power) together explain the percent of (99.8%) of the changes in the variable response to the household electricity consumption and this is a clear indication of the presence of the used logarithmic model.

It is noted that the coefficient is very high which indicates a problem with Multicollinearity, so we used Farrar Glauber test and found that the value of calculated chi-square is equal to (94.23), while the value of tabulated (chi-square) is equal to (5.99), which indicates the existence of the problem of Multicollinearity. In order to address this problem we either expand the size of the sample which is not appropriate because when the two variables are correlated at a period of time they continue in correlation [30] or delete one of the independent variables which become a big risk due to the importance of each variable used in this study. Also we can not delete one of independent variables when we deal with such behavior function, [31]. Deleting one of the variables lead to a failure of the function that govern this phenomenon. Also multi-linear regression does not cause a real problem if the main goal of the study is forecasting.

The forecasting results for the years 1986-2009 in Table 6 are consistent with the national strategy for energy and electricity sector in Jordan.

**RESULTS**

- The study proved that a growing population is an affected factor on increasing household electricity consumption.
- The average price of electricity is not an obstacle in the growing demand of household electricity consumption due to the enormous rise in oil prices and government funding to the electricity sector.
- The variable GDP play a major role in increasing the demand for household electricity consumption. There is a positive relationship between GDP and the consumption of electric power.
- The study proved that the logarithmic function is the appropriate and suitable model to measure and analyze factors affecting the consumption of electricity and for forecasting.

**Recommendations:**

- Develop informative programs for citizens to reduce rationalize the consumption of electric power in the house hold sector.
- Continue on different prices list among different consumers to motivate them in saving energy.
- Direct citizens toward the use of other energy sources such as solar energy.
- Adoption of the logarithmic function model for forecasting the decision – makers in the energy sector.

**REFERENCES**