Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2014/04/jls.htm
2014 Vol. 4 (S4), pp. 454-460/Basirat et al.
Research Article

FACTORS AFFECTING DEMAND FUNCTION OF RESIDENTIAL ELECTRICITY IN KHUZESTAN PROVINCE

***Mehdi Basirat, Ali Asghar Esfandeyari and Fariborz Sarafion**
Department of Economics, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
**Author for Correspondence*

ABSTRACT
Analysis of demand for electricity in order to identify the effective factors and their impact on consumption more precisely is of great importance. Therefore, this paper aims to estimate the function of residential electricity consumption in Khuzestan by ARDL method. To do this, Eviews and Microfit softwares were applied using data related to time series 1978-2012. According to bounds test results and dynamic model-based estimate, a long-run relationship was demonstrated. The results of long-run model estimate indicated that there is a positive relationship between the variables including temperature, number of residential electricity subscribers and the average household income and showed a negative relationship between electricity price variable and the dependent variable (electricity demand). The results obtained by Error Correction Test (ECT) suggest that the demand is corrected more quickly than its deviation from long-run equilibrium relationship; structural stability test results of the model confirm the existence of structural stability.

Keywords: *Demand Function, Price Elasticity, Income Elasticity, Khuzestan Province*

INTRODUCTION
In Iran's economy, oil products, gas and electricity have an important role to play in the country's economic and political stability and security. However, economic policies established based on easy access to energy at very low prices in Iran, prevent making consumers understand the economic importance of energy through price and cause increasing consumption and loss of it in all sectors including domestic and industrial (Mohammadi and Mohtashami, 2010).
For the public goods and services such as water, electricity and telephone with a high fixed cost of production, it is mostly the government, which is the main supplier of the goods in the market. Increased consumption of such goods along with overpopulation, lack of proper growth of supply compared to demand and disordered consumption have caused some problems in establishing equilibrium between supply and demand particularly during peak periods. In such conditions, it is very important to identify supply and demand sides in order to manage consumption and establish equilibrium (Khoshbakht *et al.*, 2011).
Planning the development of electricity generation capacity in the country requires foresight and long-run forecast of electricity demand. Electricity as one of the economic sub-sectors of Iran has two significant features compared to all other economic sectors and sub-sectors of the country that distinguishes it somehow from other sectors. The first is that necessary investment for increasing new capacities of production, transmission and distribution of electricity is very significant. The other feature is that the time to build such capacities is relatively long. A thermal power plant requires averagely ten years and a gas power plant needs at least three years starting from study, design, installation and start-up to operation. An average 25-year time should be considered for return on investment that requires short-run and long-run forecasts about electricity demand in the country (Satei, 2005). Awareness of electricity demand level in each period is necessary for planning precisely in order to enforce required policies. This issue is very important in domestic sector with a considerable share of electricity consumption. Useful information could be provided to related decision-makers about consumption procedure of residential electricity in the future and planning to supply electricity by estimating electricity demand function in Khuzestan Province (1978-2012), considering numerous problems associated with electrification network in this province. Therefore, we are going to find answers to the following question in this paper:

- Does the residential electricity in Khuzestan Province have a negative relationship with the electricity price and a positive relationship with the average household incomes, number of subscribers, substitution goods (natural gas) price and temperature?

Theoretical Principles

Theoretical principles of this paper's pattern are based on an analysis of consumer behavior in microeconomics. In this way, we may estimate residential electricity demand while obtaining parameters including price elasticity, income elasticity and cross elasticity of demand. According to consumer behavior theory, one will maximize his/her utility function consisting of a variety of goods under particular budget constraints as follows:

$$MaX \quad : U = \rho(X_1, X_2, ..., X_n)$$

$$S.T \quad : \sum P_i X_i \le B \qquad i = 1,2,...,n$$

Where X_i indicates consumption level of different goods during certain periods, P_i shows the price of such goods and B is consuming income of the consumer. If the maximization is made by common mathematical rules (Lagrange and the like), demand functions for each of goods such as residential electricity will be calculated.

$$X_e = X_e(P_e, P_G, P_{iN}, B)$$

In this model, X_e is residential electricity demand; P_e shows residential electricity price; P_G indicates the price of gas or any other substitution goods; P_{iN} suggests to average price index of all other goods and B is the household income or budget.

In this analysis, the electricity is considered as a commodity, which exists at any time with any quantity at a fixed price. Furthermore, the decisions about maintenance of household appliances are made so that there is a perfect rented competitive market for such appliances against their individual proprietorship.

With regard to the above models, residential electricity demand function could be considered as a function of electricity price, real price of substitute fuels, real household income and non-economic factors including population, weather conditions, etc.

Review of Literathre

Changi and Jalouli (2012) estimated in a study the electricity demand function and forecasted it for Iranian vision in 2025. According to the results obtained, inelasticity of electricity demand compared to its price as the result of other studies in Iran and all other countries was also confirmed in this study. Blackovis *et al.,* (2012) have investigated in their study the residential electricity in Spain. They concluded that the estimated price elasticity is negative, but less than 1 in short and long run; it shows inelasticity of demand compared to price. Moreover, weather variable indicates a dramatic effect on the electricity demand. Mirzamohammadi and Karimi (2009) have estimated consumption demand function of residential electricity in Iran in another investigation. They calculated short and long-run elasticity as 0.0852 and 0.222 respectively, and short and long-run income elasticity as 0.126 and 0.0325 respectively. Halafi and Eghbali (2005) have started to estimate demand functions of Khuzestan Province (divided into residential and industrial). The experimental results of this study showed that firstly, both residential and industrial demand of electricity are stable and balanced functions. Second, the presence of any variable of electricity substitute energy price was not confirmed. Third, price and income elasticities of electricity demand indicate inelasticity of residential electricity demand compared to price and income as well as inelasticity of industrial electricity demand compared to price and show the elasticity of electricity demand to value added of the industrial sector in Khuzestan Province. Fourth, estimating the Error Correction Model (ECM) for both functions is indicative of high speed of adjusting electricity demand model toward long-run values. Ettestol (2002) has used the data collected during 1970-1999 in Norway to estimate a linear ECM for electricity demand. The oil price coefficient being negative in the estimated function means that even if the oil prices decrease in the long-run, the electricity consumption will continue to increase. The price, income and cross elasticities suggest to low elasticity of electricity demand compared to the price and its elasticity compared to the income. Miller (2001) estimated the long-run demand in the United States. The results of his study show that price elasticity in the estimated model is -0.37 indicating the electricity goods as being essential, or expense ratio of residential electricity to total household incomes is not so important.

MATERIALS AND METHODS

Methodology

In this study, required statistical data were collected by library method. Furthermore, econometric methods were applied to answer research questions and to test related hypotheses. In other words, determining an appropriate model (using current statistics) through econometric methods and techniques as well as Microfit 4 software, coefficients were estimated as elasticity; then proper solutions will be provided using such coefficients and expressing the strength and weakness of their effects on the electricity demand in the related function and analyzing the results so achieved.

To investigate long and short-run relationships between the dependent variable and other explanatory variables of the model, ARDL (Autoregressive Distributed Lag) approach was used after ensuring a co-integration vector. The estimated made through ARDL method are unbiased and efficient due to avoiding problems like autocorrelation and endogen (Dickey, 2000).

ARDL model consists of two stages in the first of which the long-run relationship between the variables in question will be tested. The maximum number of lags is considered considering the number of observations and the Schwarz Bayesian Criterion (SBC) shows better results in the observations less than 100 due to its tendency to shorter specification (Tashkini, 2005).

Presence or absence of long-run relationships should be tested immediately after estimating the dynamic equation (short-run). Now, to examine the truth of the long-run relationship resulted by this method, we shall do as following and test the related hypothesis.

$$H_\circ = \sum_{i=1}^{P} \phi - 1 \geq 0$$

$$H_1 = \sum_{i=1}^{P} \phi - 1 < 0$$

The null hypothesis (H_0) indicates the lack of a long-run relationship, because a short-run dynamic relationship would tend toward long-run equilibrium, if the total coefficients were less than one. The t-value for the test in question will be calculated by deducting one from total coefficients with the dependent variable lag and dividing into total standard deviation of the related coefficients.

$$t = \frac{\sum_{i=1}^{p} \hat{\phi}_i - 1}{\sum_{i=1}^{p} S\hat{\phi}_i}$$

In this equation, S shows standard deviation of coefficients with dependent variable lag. If the resulted absolute t-value is higher than absolute critical values provided by Banerjee *et al.,* the null hypothesis is rejected and the presence of a long-run relationship is proved. Confirming the presence of a long-run relationship between the variables, the ECM model could be used.

Moreover, to examine the long-run relationship, one may make use of Bounds testing approach formulated by Pesaran *et al.*, (2001) based on an approach to estimate Unconstrained Error Correction Model (UECM) including dynamic and long-run equilibrium relationships. In this model, the presence of a long-run relationship between the variables under study will be examined through calculating F statistics in order to test significance level of the lagged variables in the form of error correction. If the computational F is beyond the upper limit, the null hypothesis based on the presence of long-run relationship will be rejected and if it is below the lower limit, the mentioned null hypothesis will be confirmed.

The second stage of this analysis includes using ARDL choices in estimating long-run relationships and related statistical inference to their values. It should be noticed that commencement of this stage is appropriate only when we convince that the relationship between the variables are not false.

Experimental Results

Identification and Clarification of the Model

In this section, taking advantage of theoretical arguments and experimental considerations, an appropriate model for residential electricity demand function in Khuzestan Province is introduced as follows. In this study, we used the model already applied in an investigation performed by Vincenzo (2009).

$LED = \alpha_0 + \alpha_1 LEP + \alpha_2 LDH + \alpha_3 LFA + \alpha_4 LPG + \alpha_5 LHI$

Where, LED suggests to logarithm of electricity demand, LEP is logarithm of average electricity price, LDH shows the logarithm of average temperature of the province, LFA suggests to the logarithm of household income, LPG is the logarithm of gas price and LHI is the number of the subscribers of residential electricity in this province.

All data and statistics required for this study were collected from official resources published by electrical distribution office in Khuzestan Province, Statistical Center of Iran, energy balance sheet and Meteorological Organization of Iran. In this investigation, annual statistics related to time series 1978-2012 was used.

Evaluation of Variables Stagnation

The stagnation and/or non-stagnation of the variables should be ensured before using them. The statistics applied in this investigation is Augmented Dickey-Fuller (ADF) statistics. Unit root of the variables of this study were examined using Microfit 4.

Accordingly, time series of the variables including temperature and gas price are stagnant at the data level. In other words, computational statistics for the said variables in the optimal lag are higher than absolute value of the calculated test and the null hypothesis or non-stagnation of the variables could be rejected at the confidence level of 95%. Then, the above test is applied for first-order difference equations. According to the results obtained, all variables are static at differencing.

Table 1: The results of Dickey-Fuller reliability test generalized on the variables level and difference

	Test results at variables level The presence of intercept and absence of linear trend in data				Test results in variables difference The presence of intercept and absence of linear trend in data			
Variable name	**SBC measure**	**ADF statistic based on SBC**	**The critical value of ADF at %95**	**Variables reliability**	**SBC measure**	**ADF statistic based on SBC**	**The critical value of ADF at %95**	**Variables reliability**
LED	-78/19	-1/18	-2/94	unstable	-77/63	-4/29	-2/94	stable
LEP	-73/03	-2/50	-3/54	unstable	-74/32	-4/93	-3/54	stable
LDH	25/74	-5/12	-2/94	stable	-	-	-	-
LFA	-73/57	-1/65	-2/94	unstable	-72/82	-5/03	-2/94	stable
LPG	-49/61	-3/55	-2/94	stable	-	-	-	-
LHI	-55/45	-1/76	-3/54	unstable	-57/49	-6/79	-3/54	stable

Bounds Test and Long-run Relationship Demonstration

The F statistics is used now to investigate whether all coefficients are equal to zero (it means that there is no long-run relationship). Since this statistic has no standard distribution, regardless of whether the variables are I(1) or I(0), the critical values offered by Pesaran *et al.*, (1996) should be used. There are five regressors and the above pattern has a constant term. On one hand, the model consists of both I(1) and I(0) variables. Therefore, both upper limit and lower limit critical values are considered as a basis. Since at the level of 95%, the upper limit is 3.81 and the lower limit is 2.65 (table 2) and the computational F-value for significance testing of all coefficients is higher than upper limit (5.73), the null hypothesis for the lack of long-run relationship could be rejected.

Table 2: Test F for Long-run Relationship Demonstration

F statistics	at the level of 95%		at the level of 90%	
	I(1)	I(0)	I(1)	I(0)
5/73	805/3	649/2	367/3	262/2

Estimation of Dynamic Model

According to a study carried out by Pesaran *et al.,* (2001), the long-run coefficients of compatibility between variables in question could be calculated using ARDL model and considering proper lags. In Johansson's model, identical lags are selected for all variables while in ARDL model, optimal lags are selected for single variables using criteria including Schwartz, Basianm, Akaike and Hannan Quinn.

Based on the estimated results, there has been no problem of autocorrelation or variance anisotropy, normality and consequential form in this model and the model specification has been acceptable. The coefficient of determination is equal to 0.86 (showing that 86 percent of changes in residential electricity demand in this province are explained by independent variables) and F-value is 26.38 indicating the high explanatory power of the model.

In ARDL model, the long-run co-integration relationship is verifiable when absolute t-value is greater than absolute critical value (to do this test, total lagged coefficients of independent variable should be deducted from one and divided by its standard deviation.).

The computational statistic is obtained as follows:

$T=\frac{.2382-1}{.1367}$ = -5/5727

Comparing the computational statistics (-5.57) with critical absolute value of this test at the level of 95 percent (-4.43) introduced by Banerjee *et al.,* the long-run relationship hypothesis (co-integration) between the model's variables are verified. Thus, the model is estimated as long-run.

Estimation of Long-run Relationship

Estimating the dynamic model (short-run) and proving the long-run relationship, this relationship is estimated. The results of long-run estimation are shown in table 3.

Table 3: Results from the long term estimation

Variables	Coefficients	Statistic t
LEP	-0/7219	0/2284(0/002)
LDH	1/3772	0/3148(0/000)
LFA	0/8115	0/2759 (0/007)
LPG	0/0027	0/3906 (0/994)
LHI	1/6909	0/3374(0/000)
C	18/0241	0/7316(0/013)

Since the mentioned model is a linear-algorithmic form, the coefficients of independent variables explain the elasticity.

According to the estimated results, electricity price variable is significant and its coefficient is negative based on theoretical expectations. This variable indicate that (supposing all other variables as fixed) increasing the electricity price by one percent, electricity demand will be decreased up to 0.72; the temperature variable is also significant and its coefficient is positive based on theoretical expectations; this suggests that 1 percent increase in the temperature, electricity demand will be increased up to 1.38 percent. The average household income variable is significant the related coefficient is indicative of a positive effect on the electricity demand. This variable (with coefficient as 0.81) expresses that a change of one percent in the average household income will increase the electricity demand by 0.81; gas price variable has not been significant at the levels of 5% and 10%; the variable of the number of subscribers of residential electricity is significant and has a positive and direct relationship between the electricity

Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2014/04/jls.htm
2014 Vol. 4 (S4), pp. 454-460/Basirat et al.
Research Article

demand. This variable shows that increased number of subscribers will raise the electricity demand by 1.69 percent.

Estimation of Error Correction Model (ECM)

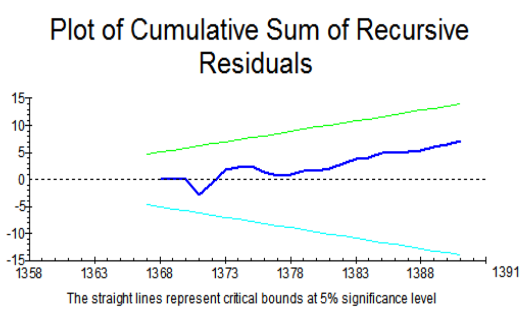
The ARDL model adjusts and estimates ECM model to examine short-run deviation of variables from their equilibrium values. Since the presence of long-run relationship was confirmed in higher regressions, now we continue to examine regression error correction model. The most important issue in ECM is error correction term coefficient (ECM-1) indicative of the speedy adjustment of imbalance process. As it is seen, this coefficient is significant and negative that confirms the co-integration between the variables. According theoretical expectations, if we move from a term to another, 76% of the deviation level in electricity demands function from its long-run path will be corrected in the next term by the model's variable. Therefore, movement toward equilibrium takes place relatively quickly.

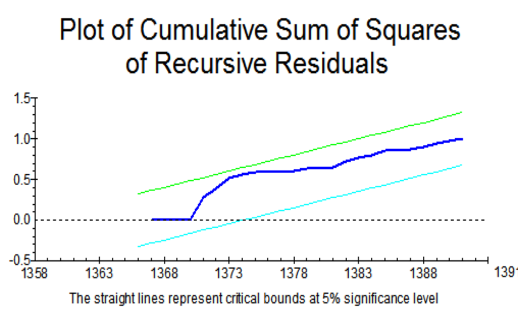
Table 4: The results of Error-Correction coefficient

Variables	Coefficients	standard deviation	Statistic t
dLEP	-0/5646	0/2071	-2/7255 (0/008)
dLEP(-2)	0/4145	0/1322	3/1357 (0/004)
dLDH	1/049	0/2788	3/7618 (0/001)
dLFA	0/6181	0/2086	2/9622 (0/006)
dLPG	0/0020	0/2976	0/0070 (0/994)
dLHI	1/2880	0/2743	4/6951 (0/000)
dC	13/7293	4/7049	2/9181 (0/007)
ECM(-1)	-0/7617	0/1367	-5/5693 (0/000)
R^2	0/6314		
F	9/21		(0/000)
D.W	2/23		

The Results of Structural Stability Test

The coefficients stability was examined using CUSUM and CUSUMSQ; the results show that coefficients of the estimated model have been stable during the term under question. As shown by the results of estimation and in the residual cumulative flow and squares, confidence interval of 5% was not interrupted by the flows; therefore, the null hypothesis based on the structural stability of the parameters is verified.





Conclusion and Suggestions

Short-run and long-run price elasticity in this model is less than 1. it should be noted about the power consumption that such commodity is irreplaceable and this situation will be enhanced as the life becomes more mechanized and shows the necessity of electricity. This issue is more clarified particularly by calculating income elasticity in short-run and long-run. Being smaller than 1 indicates that the electricity is essential; on one hand, lower price elasticity shows minor impact of price changes on the electricity demand during the period under investigation and on the other hand, it suggests to lack of appropriate replacement for electricity in the residential sector. However, the most important reason for the price elasticity being small could be considered in low-cost share of residential electricity of the total budget. The price elasticity is 0.81 in long-run indicating that the electricity is an essential commodity in family consuming basket. Therefore, demand does not show so much reaction to income changes; the temperature variable is indicator of the number of days we need to cooling devices. The positive coefficient shows that the consumption will increase as the temperature rises. However, this issue has been more featured in the recent years, as the use of unit air-conditioner and higher purchase power of the people. Common use of highly used air-conditioners is one of the challenges in the consumption pattern of the society that has forced related people to exercise incremental prices; gas price variable entered in the model as the substitute commodity (cross elasticity of demand), is not significant. The result was achieved due to impossibility to substitute gas with the electricity in the province, because the people in Khuzestan Province make use of electricity energy as a way to adjust the high temperature., for the gas could not been used as a substitute to electricity in this province; the number of household customers is an important and effective variable in the demand of residential electricity. One percent increase in the number of households in the province, the power consumption will increase in the long-run as 1.69 percent. In other words, electricity demand has elasticity compared to the number of subscribers. Application of other methods such as informing people about how to use this commodity properly, substituting it with all other fossil fuels, if possible, could help reduce power consumption in case we face power shortage. Furthermore, we should provide greater supply through greater investment and increasing the production, while reducing incremental trend of demand in the household sector by applying non-price policies (including use of Compact fluorescent lamps (CFL)) in order to reduce increasing trend of demand somewhat in household sector.

REFERENCES

Bianco V, Manca O and Nardini S (2009). Electricity consumption forecasting in Italy using linear regression models. *Energy* **34**(209) 14-21.

Blázquez L, Boogen N and Filippini M (2012). Residential electricity demand for Spain: new empirical evidence using aggregated data. CEPE Working Paper No. 82.

Changi Ashtiani Ali and Jalouli Mahdi (2012). Estimation of electricity demand function and prediction of it for the vision 2025. *Economic Growth and Development Quarterly Journal*, year 2 (7).

Halafi Hamidreza and Eghbali Alireza (2005). Estimation of electricity demand functions in Khuzestan Province (divided into residential and industrial). *Quantitative Economics* **2**(1).

Khoshbakht Ameneh, Raghfar Hossein and Khiabani Nasser (2011). Estimation of water demand function in household sector with non-linear prices, using discrete – continues choice model, *Water and Wastewater* (2).

Mirzamohammadi Saeid and Karimi Saeid (2010). Estimation of demand function of residential electricity consumption in Iran, The 2nd global conference on modification of consumption pattern of electrical energy in Ahwaz.

Miller James Isaac (2001). Modeling Residential for Electricity in the USA, *Journal of Economic Literature*.

Mohammadi Hossein and Mohtashami Mina (2010). An investigation into the factors effective in the electricity demand in industrial sector. The 2nd global conference on modification of consumption pattern of electrical energy.

Satei Mahsa (2005). Estimation of electricity demand function in Iranian industrial sector (1967-2002). MA Thesis, Islamic Azad University, Khorasgan Branch.

Siddiki JU (2000). Demand for Money in Bsngladesh: A Contegration Anlysis. *Applied Economics* **32** 1977-1984.

Tashkini Ahmad (2005). Applied econometrics by the help of Microfit. 1st ed., Tehran: Cultural and Artistic Institute of Dibagarn Tehran. Available: www.cepe.ethz.ch.