Projected Residential Electricity Demand After Subsidies Reform Program In Iran

Mehdi Sadeghi Shahdani[1], Zohreh Salimian [2], Majid Aghaee[2], Vahab Mokarizadeh[2]

[1]Economics Department of Imam Sadegh University, Iran, +982188081404, sadeghi@isu.ac.ir

[2] Niroo Research Institute, Iran, +982188079396, zsalimian@nri.ac.ir, vmokarizadeh@nri.ac.ir

Overview

At present, removal the corresponding subsidies in various subsectors, particularly in residential sector, is of the most important challenges, which are about to happen in energy sector in Iran. In this regard, subsidies of all energy carriers including electricity, natural gas and other fuels will be removed and the prices will be increased to the production cost over a five-year plan, which lasts until 2014. The effects of any price reform on demand rely on the price elasticity of electricity demand. The estimated elasticities, for the two GMM residential electricity demand models show that demand is income and price inelastic while economic growth is noteworthy in determining electricity consumption. The estimated own price elasticities are -0.104 and -0.0332, respectively. Since income elasticities are also below unity, 1% increase in the income growth supposedly culminate in a less than proportional rise in electricity demand. Finally, the 30-year forecast shows that electricity demand will grow up annually at average rates of 5.37%, 4.77%, 5.75%, 5.15%, 6.62% or 6.01% per year through different scenarios.

Key Words: Residential, Electricity Demand, Subsidies Reform Plan

JEL: C01, C22, C53

1. Introduction

With an electricity demand of 2800kWh per capita in 2009, Iran's residential electricity demand has been growing at an average of 5.2% during past decade. In 2009 household consumption accounting for about 33% of total electricity consumption [6,10]. In 2010 the Iranian targeted subsidy plan was executed to replace subsidies on food and energy (80% of total) with targeted social assistance, in accordance with Five Year Economic Development Plan and move towards free market prices in a 5-year period [18]. Consideration of the effects of this price increase and GDP growth on the residential electricity demand is of crucial importance, due to which this study is conducted.

Several authors have studied the role of structural changes in residential demand for electricity such as Suleiman Sa'ad in South Korea[15]. He studied time series data for the period from 1973 to 2007 is used in a structural time series model to estimate the long-term price and income elasticities and annual growth of underlying energy demand trend (UEDT) at the end of the estimation period. The result shows a long- term income elasticity of 1.33 and a long-term price elasticity of -0.27% with -0.93% as the percentage growth of UEDT at the end of the estimation period. This result suggests that, in order to encourage energy efficiency in the residential sector, the government should complement the market based pricing policies with non-market policies such as minimum energy efficiency standards and public enlightenment[15].

Furthermore, Himanshu and Hunt [9], Kamerschen and Porter [11], Atakhanova and Howie [2], Filippini and Pachauri [7], Nakajima [13], Tiwari [16] studies on the residential demand of electricity in different countries. However, in Iran, there have been such studies as Aminifard[1], Pourazarm[14] and Lotfipour [12] about the estimation of the residential electricity demand function.

The structure of the household consumption of electricity varies significantly between regions and countries. These variations are due to differences in economic factors such as real electricity prices, household's income and efficiency improvements as well as structural and behavioral factors such as socio-demographic factors, climatic condition, living standards, and household lifestyles. However, for long time, energy modelers in developing countries only concentrate on economic factors such as real energy prices and household incomes and sometimes including factors such as urbanization or changes in household appliance use as additional explanatory variables. As with the household's income, electricity price is another important factor affecting electricity demand. High electricity price may cause households to use less energy in the short-term. In the long-term, this will stimulate the purchase of more efficient appliances whose end product is expected to bring about a substantial reduction in electricity use at a given prices. Accordingly, it is expected that there exist a negative correlation between electricity prices and household's consumption of electricity [15]. At present, removal the corresponding subsidies in various subsectors, residential in particular, is of the most important challenges, which are about to happen in energy sector in Iran. This paper is generally focused on the effect of energy price increases on residential electricity demand in Iran based on the estimation of GMM Model and calculating price elasticity of demand, which is a function of electricity consumption, electricity price, gas price, heating and cooling degree days and household consumption expenditures. In the following section, the theoretical framework and the empirical specification of the electricity demand model will be specified.

2. Theoretical Framework

The primary object of interest in many estimation procedures in econometrics is simply as function of moments. Most estimation procedures are a specialization of the GMM estimation principle. GMM estimation method includes Ordinary Least Squares (OLS) as a special case and provides a solution. Identification of GMM which is an IV estimator may well begin with the simple linear regression noted below;

$$y = X\beta + \varepsilon \tag{1}$$

where y represents a (n×1) vector containing the values of the dependent variable and the error term ε has mean zero and variance σ^2 and is distributed as $Q(0,\sigma^2)$. Q, is a kind of distribution which is not necessarily normal. X is a (n×k) matrix and also allows for the intercept term along with independent variables. n and k are the number of observations and variables respectively. Finally, β denotes the (n×1) parameter vector. When the model in Eq. (1) correctly specified, $E(X'\varepsilon)=0$. In the population, $E[X'(y-X\beta)]=0$ with the fact that $\varepsilon=y-X\beta$. If $E[X'(y-X\beta)]=0$ is assumed, β is not known.

The left-hand side of $E[X'(y-X\beta)]=0$, known as a moment or ortogonality condition, with its sample analog $\frac{1}{n}X'(y-X\hat{\beta})=0$ can be replaced according to the MOM principle. The true β sets the population moment equal to zero in expectation, whereupon it can be assumed that a good choice of ^β would be one that sets the sample moments to zero. The MOM procedure suggests an estimate of β that solves $\frac{1}{n}X'(y - X\hat{\beta}) = 0$. Since, the MOM can be generalized by allowing the moment to depend on unknown parameters β , the solution turns out to be a set of *k* simultaneous equations with *k* unknown parameters. Hence, a unique solution for ^β that satisfies $\frac{1}{n}X'(y - X\hat{\beta}) = 0$ can be found. The MOM estimate is $\hat{\beta}_{MOM} = (X^{'}X)^{-1}X^{'}y$ [17].

The assumption that there are a set of *l* moment conditions that the *k* -dimensional parameters of interest, β should satisfy, is the starting point of GMM estimation. A model has often more specified moment conditions than parameters to be estimated. Therefore, $E(m(y_t, \beta)) = 0$ is the vector of *l* ≥ *k* moment conditions. Moment conditions that may be written as an orthogonality condition between the residuals of an equation, $u_t(\beta) = u(y_t, X_t, \phi)$, and a set of *k* instruments $Z_t : E(Z_t u_t(\beta)) = 0$ .By replacing the moment conditions in $E(m(y_t, \beta) = 0$ with their sample analog $m_T(\beta) = \frac{1}{T}\sum_t Z_t u_t(\beta) = \frac{1}{T}Z^{'}u(\beta) = 0$, MOM estimator is defined. Thereby, the parameter vector β which solves this set of *l* equations, is found [17]. The system of equations in $m_T(\beta) = \frac{1}{T}\sum_t Z_t u_t(\beta) = \frac{1}{T}Z^{'}u(\beta) = 0$ may not have a solution if there are more moment conditions than parameters (*l*>*k*). Thus, such a system is over identified. This problem can be reformulated as one of choosing a β so that the sample moment $m_T(\beta)$ is as “close” to zero as possible, where “close” is defined using the quadratic form:

$J(\beta, \hat{W}_T) = Tm_T(\beta)^{'} W_T^{-1} m_T(\beta)$. The GMM estimate is defined as the β that minimizes $J(\beta, \hat{W}_T) = Tm_T(\beta)^{'} W_T^{-1} m_T(\beta)$. The value of the objective function, termed the *J* -statistic, can be used as a test of over-identifying moment conditions [17]. Under the null hypothesis that the over identifying restrictions are satisfied, the *J* -statistic is asymptotically χ^2 with degrees of freedom equal to the number of over identifying restrictions.

The GMM objective function is $J(\beta, \hat{W}_T) = \frac{1}{T}(y - X\beta)^{'} Z\hat{W}^{-1}{}_T Z^{'}(y - X\beta)$ where the $u_t(\beta)$ are the residuals from a linear specification so that $u_t(\beta) = y_t - X_\beta^{'}\beta$. GMM estimator yields the solution $\hat{\theta} = (X'Z\hat{W}_T^{-1}Z'X)^{-1}X'Z\hat{W}_T^{-1}Z'y$. In order to specify a GMM estimator, the choice of the weighting matrix, $\hat{W}_T$ becomes important. Any sequence of symmetric positive definite weighting matrices $\hat{W}_T$ yields a consistent estimate of β. Also, the choice of $\hat{W}_T$ affects the asymptotic variance of the GMM estimator. At this point, Heteroskedasticity and Autocorrelation Consistent (HAC) weighting matrix can be used a method to specify a weighting matrix. (HAC) weighting matrix is a estimator of the long-run covariance matrix of $\{Z_t u_t(\beta)\}$ based on an initial estimate of β [17].

3. Definition of socio- economic development scenarios

The possible future energy demand of the country has been considered for the next 30 years according to the future economic development of the country and energy price subsidy reform plan. Therefore, Six scenarios have been constructed according to the proposed development of the Iranian economy and trend of energy prices through 2040 .

The first is a high socio- economical development scenario (HS) that is characterized by high GDP growth rate of 7%. The second scenario has an average GDP growth rate of about 4.6% during the past 15 years (MS). The third scenario can be considered as reference scenario with the lowest GDP growth rate (2.67%)(LS).

In addition to economic development scenarios we have energy price scenarios. Under the high energy prices scenario (HS), the real price of gas and electricity rise by up to 5 percent thru 2014[1] and will remain constant until 2040. The second is the scenario with lower annual growth rate. We assume that annual increase of real prices will be 2% until 2014 (LS).

In what follows we use a GMM model to describe residential electricity demand in Iran. According to the above- mentioned development scenarios, six different development trends of the possible future final electricity demand of the country anticipated.

4. Empirical Results

Table 1 presents the Augmented Dickey– Fuller test for the variables, electricity consumption(ED), real electricity price (P_e), real gas price (P_g), heating and cooling degree days (HDD, CDD), national income(NI) and private consumption(HC) used in the analysis.

[1] The last year of Iranian subsidy reform plan

Table 1

ADF statistics testing for a unit root

Variable	Augmented Dickey– Fuller statistics	critical values for the t-tests at the 1 percentage levels	critical values for the t-tests at the 5 percentage levels	critical values for the t-tests at the 10 percentage levels	Result
Ln(ED_t),	-6.371	-3.6156	-2.941	-2.6091	I(0)
Ln(HC)	-3.753	-3.621	-2.943	-2.610	I(1)
Ln(p_e)	-5.240	-3.621	-2.943	-2.610	I(1)
Ln(p_g)	-6.2929	-3.621	-2.943	-2.610	I(1)
Ln(HDD)	-4.522	-3.6156	-2.941	-2.6091	I(0)
Ln(CDD)	-8.215	-3.621	-2.943	-2.6103	I(1)

We find that for private consumption, real electricity and gas prices and cooling degree days series in Table 1 the null hypothesis of a unit root in the level cannot be rejected. The ADF statistic suggests that these variables are integrated of order one, I(1).

We perform GMM estimation on two versions of the following abbreviated model with parameters:

$$Ln(ED_t) = c + \alpha_d LnED(-1) + \alpha_e Lnp_e + \alpha_g Lnp_g + \alpha_{hdd} LnHDD + \alpha_{cdd} LnCDD + \alpha_{hc} LnHC \qquad (2)$$

$$Ln(ED_t) = c + \alpha_d LnED(-1) + \alpha_e Lnp_e + \alpha_g Lnp_g + \alpha_{hdd} LnHDD + \alpha_{cdd} LnCDD + \alpha_{hc} LnNI \qquad (3)$$

Where:

Ln(ED_t), Ln(ED_t(-1))	Log electricity consumption in million kWh (-1 indicates the lag term)
p_e	Log real electricity price in rials per kWh
p_g	Log real gas price in rials per cubic meter
HDD	Log heating degree days
CDD	Log cooling degree days
NI	Log National Income in billion Rials
HC	Log private consumption in billion Rials
C	Constant

In the residential electricity demand presented in Table 2, all the estimated coefficients, including the standard deviation errors and t-statistics, are available.

Table 2

GMM residential electricity demand model estimation results

	First Model			Second Model		
Variables	**Coefficients**	**standard deviation errors**	**t-statistics**	**Coefficients**	**standard deviation errors**	**t-statistics**
Constant	0.3574	0.16789	2.12881	-0.1481	0.4912	0.7648
LED(-1)	0.7511	0.04596	16.343	0.9085	0.0348	0.0000
HC	0.2783	0.05557	5.0077	-	-	-
Lnp_g	-0.0234	0.01254	-1.86685	0.0361	0.0331	1.0911
Lnp_e	-0.1041	0.03477	-2.9944	-0.0332	0.0260	-1.276
LHDD	0.1938	0.03114	6.2231	0.1686	0.0795	2.1221
LCDD	0.1604	0.03111	5.1583	0.1287	0.0810	1.5893
NI	-	-	-	0.0454	0.0131	3.4690
Dummy	0.11286	0.01863	6.056562	0.1035	0.04298	2.4078
Sargan--statistic	0.01406	prob=(0.0021)		0.0129 prob=(0.003)		
R-squared		0.9989			0.99896	
R^2-adjusted		0.9987			0.9987	
DW		2.1546			2.1269	

5. Estimation of elasticities of the residential electricity demand

One of the main objectives of this paper is to estimate the price elasticity, as well as the income elasticity. Table 3 shows the estimation results of the elasticities of the demand.

Table 3

Estimation results of elasticities

Cross elasticities (electricity and gas)		Income elasticity		Price elasticity	
Long-run	**Short-run**	**Long-run**	**Short-run**	**Long-run**	**Short-run**
-0.092	- 0.023	1.116	0.278	-0.417	- 0.104

First, the price elasticity is negative as expected. As the absolute value of the price elasticity is smaller than one, the residential electricity demand is not price-elastic. Second, the income elasticity is positive and the residential electricity demand is income-inelastic in short- run. This means that the income rise does not induce a big increase in the residential electricity demand in short- term.

6. Analysis of electricity demand projection

Figs. 1 and 2 below, display the development of residential electricity demand for the HS and LS energy price and the HS, MS and LS economic development scenarios.

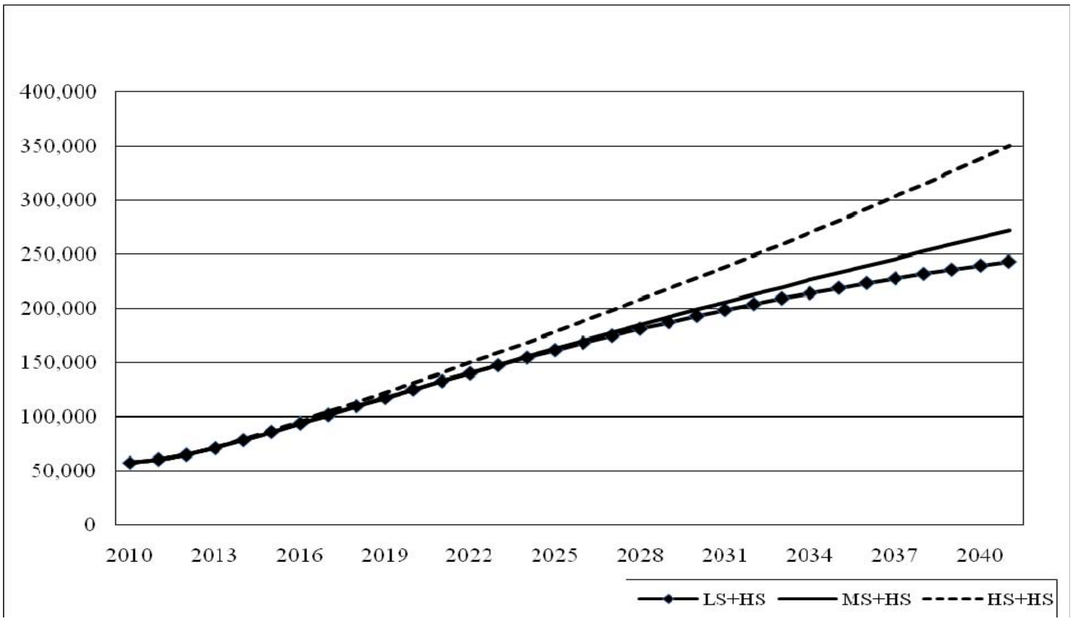

Fig.1. Evolution of electricity demand for HS energy price scenario

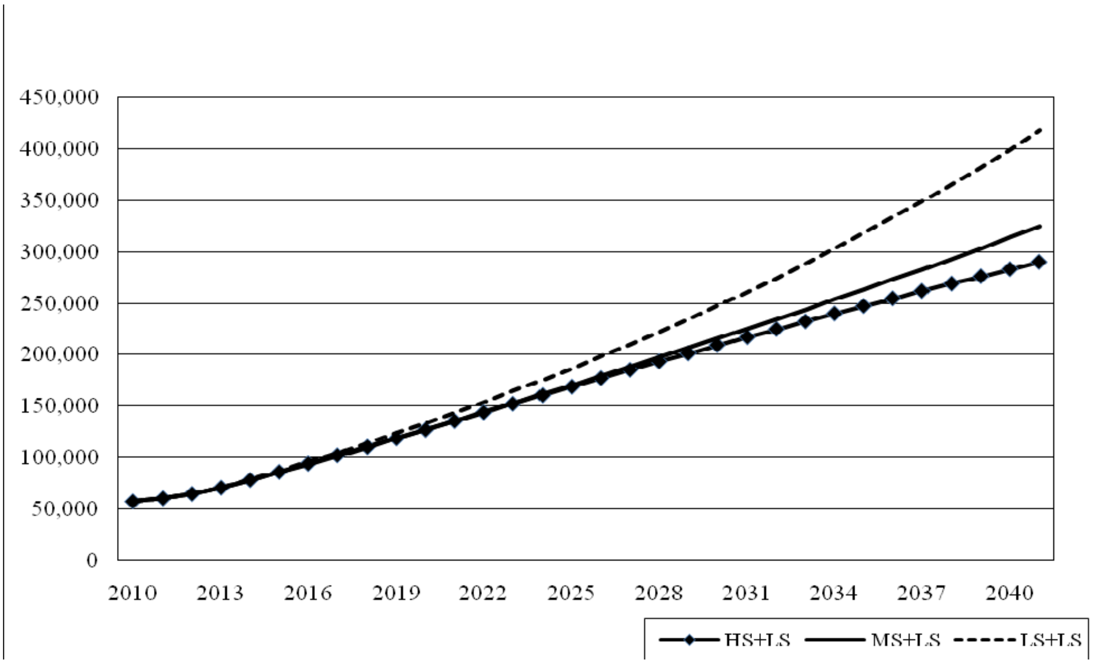

Fig.2. Evolution of electricity demand for LS energy price scenario

Our forecast shows that electricity demand will grow up annually at average rates of 5.37%, 5.75%, or 6.62% per year for the LS, MS and HS scenario of GDP growth and LS scenario for energy prices. The growth rate will amount 4.77%, 5.15% or 6.01% for the GDP growth scenarios and HS scenario for energy prices. Hereafter, the evolution of electricity consumptions differs considerably for the price rise scenarios. The relatively high values of energy prices decreases the demand for household electricity consumption which is responsive to changes in electricity tariffs.

7. Conclusions

Firstly, the estimation results of this model indicate that price elasticity of demand in residential sector is low. However, elasticity of residential electricity consumption to price changes in the period between 1967 up to 2008 is weak and it is because energy prices was subsidized during that time. This fact suggests that there is considerable capacity for price increases necessary to finance generation and distribution system. Secondly, a priori, we expect increases in the income variables to have positive impacts on electricity demand; however, we find that income elasticity of electricity demand is less than unity reflecting saturation effects given that household appliance use and lighting are necessities and unlikely to be much affected by rising income.

8. Aknowledgment

This article is part of research results of project “Long- term Demand Forecast up to 1420 Considering Subsidy Omitting, Energy Consumption, Decentralized Generation and Renewable Energy Using”, which is sponsored by Niroo Research Institute.

References

1. Aminifard Abbas (2002), "The Estimation of Residential Demand for Electricity in Iran: A Cointegration Approach (1967-1999)", M.A Thesis (Economics), Shiraz University (In Persian)
2. Atakhanova Zauresh and Howie Peter (2007), "Electricity demand in Kazakhstan", Energy Policy 35 , 3729–3743
3. Bowerman, Bruce L. and O’Connell Richard T. (1979), "Time Series and Forecasting: An Applied Approach", New York: Duxbury Press.
4. Enders Walter, applied econometrics time series, 2 nd. Edition. Iowa State University of New York
5. Energy and Load Management Department of Niroo Research Institute (NRI). Long- term Demand Forecast up to 1420 Considering Subsidy Omitting, Energy Consumption, Decentralized Generation and Renewable Energy Using, report no.2. Tehran, Niroo Research Institute, 2010 (In Persian).
6. Energy Balance of Iran, Power and Energy Planning Department, Ministry of Energy, 1967-2009
7. Filippini Massimo and Pachauri Shonali (2004), "Elasticities of electricity demand in urban Indian households", Energy Policy 32, 429–436
8. Greene W.H.(1990), Econometrics Analysis, New York, Academic press, 2nd edition

9. Himanshu A. Amarawickramaa and Lester C. Hunt(2008), " Electricity demand for Sri Lanka: A time series analysis ", Energy 33 (2008) 724–739
10. Iran Power Industry's Annual Reports, Tavanir Organization, 1967-2011
11. Kamerschen David and David V. Porter (2004), " The demand for residential, industrial and total electricity, 1973–1998 ", Energy Economics 26 (2004) 87–100
12. Lotfalipour M.R (2004), "The Survey and the Estimation of Effective Factors on Household Electricity Demand in Khorasan Province", Knowledge and Development 2004-2005, (15):47-68
13. Nakajima Tadahiro (2010), "The residential demand for electricity in Japan: An examination using empirical panel analysis techniques", Journal of Asian Economics 21 412–420
14. Pourazarm E (2005), "Residential Electricity Use Demand Estimation In Khuzestan Province ", Journal of Economic Essays Fall-Winter 2005-2006, 2(4):137-182
15. Sa’ad , Suleiman (2009), "Electricity demand for South Korean residential sector", Energy Policy 37 5469–5474
16. Tiwari, Piyush (2000), "Architectural, Demographic and economic causes of electricity consumption in Bombay", Journal of policy modeling, Vol.22 , No.1
17. Yildirim N, Oguzhan Ozcelebi and Suna Mugan Ertugral (2011), " Effects of Inbound and Domestic Tourism Demand on Tourism Investments in Turkey: A Generalized Method of Moments Model", Middle Eastern Finance and Economics, Issue 10
18. Wikipedia [Internet, page was last modified on 19 August 2011 at 23:20]. Available from: http://en.wikipedia.org/wiki/Iranian_targeted_subsidy_plan