Estimating agricultural demand for electricity in Iran (1975-2007)

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High electricity consumption in agricultural sector is an important issue in Iran economy. The main reason is the low price of electricity. In this study we estimated demand function of electricity in agriculture sector (1975-2007) using ARDL method. Results indicated that (1) the short-term & long-term price elasticity is -0.1 and -0.49, respectively, (2) short-term & long-term income elasticity is 0.43 and 2.07, respectively, and (3) the lagged error correction term was significant with expected negative sign (-0.21).The CUSUM and CUSUMSQ tests have been done and the results showed a stabilization of coefficient in confidence level 5%.

Keywords: electricity demand, ARDL, elasticity

1. Introduction

High electricity consumption in agricultural sector in Iran is an important issue that Price liberalization and omitting electricity subsidy is one of the solutions to reduce electricity consumption in agriculture sector. Electricity price in Iranian agriculture sector is 21 rials per kilowatt /h while cost Price is 834 rials per kilowatt /h in 2007 and agriculture sector use 8% of total electricity use in Iranian economy. In this study we applied CPI index to calculate real price. The investigation of nominal and real price of electricity for the period 1975-2007 shows that in spite of increasing nominal price of electricity between these years, the real price decreased. Also, results showed that the average growth of electricity consumption in agricultural sector was 14%. Because of some facts such as low price of electricity in Iran, none existence of a suitable substitution, high consumption and its effects on macroeconomic variables it would be necessary to investigate the main factors which affects the electricity consumption in agricultural sector. Therefore this study

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aimed to estimate long and short- term electricity consumption function in agricultural sector in Iran.

A few recent examples for these studies are noted here: (Filippini - Pachauri 2004) for urban Indian households; (Dergiades - Tsoulfidis 2008) for residential in theUnited States; (Narayan - Smyth 2005) for residential in Australia; (Amusa et al. 2009) for Aggregate electricity demand in South Africa; (Zachariadis - Pashourtidou 2007) for Cyprus; (Razak - Al-Faris 2002) for GCC countries; (Kumar et al. 1999) for India show that electricity consumption in agriculture sector are income inelastic (<1). The short – run price elasticity is -1.35 in agriculture sector; (Atakhanova - Howie 2007) in Kazakhstan. This paper estimates Kazakhstan's aggregate demand for electricity as well as electricity demand in the all sectors . Results show that firstly, price elasticity of demand in all sectors is low. Secondly, income elasticity of demand in the aggregate and all sectors is less than unity.

The paper is organized as follows: After the introduction the second section is provides the econometric specification of the model for agricultural demand for electricity and discusses the ARDL cointegration technique. The third part presents the data and evaluates the results of the econometric analysis. Finally there is a conclusion and recommendation regarding to the results of the study.

2. Electricity Price in Iran

Figure 1.

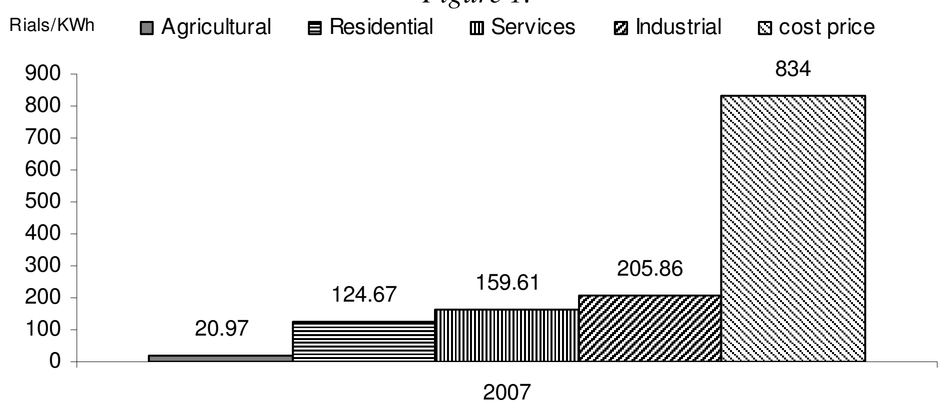

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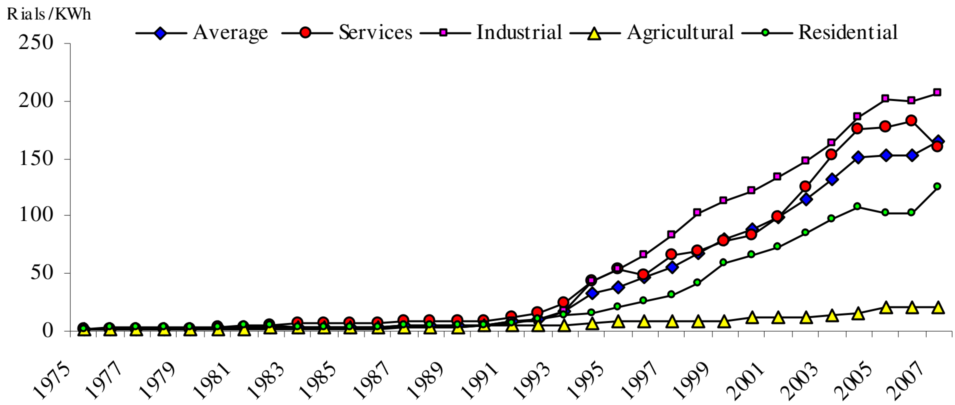
Figure 2.



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3. Model and methodolpogy

A modified agricultural electricity demand model in logarithmic form is adopted based on :

$$\ln Co_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 \ln P_t + \alpha_3 D_t + \varepsilon_t \quad (1)$$

Where Co_t is the agricultural electricity consumption (KWh) , Y_t is the real added value in agricultural sector, P_t is the real agricultural electricity price (rials/KWh) and D is the dummy variable for drought in Iran that occur in 1988 and 1989 ln is the natural logarithm transformation.

As for the expected signs in Eq. (1), one expects that $\alpha_1>0$ because higher added value in agricultural sector should result in greater economic activity and accelerated purchases of electrical technology. The coefficient of price level is expected to be less than zero for usual economic reasons, therefore, $\alpha_2<0$. The coefficient of dummy variable is expected to be more than one because drought in 1988-1989 cause to decrease the agricultural product.

In the last two decades, several econometric procedures were employed to investigate the electricity demand functions. With regards to cointegration approaches, there are several example including (Engle - Granger 1987, Narayan - Smyth 2005, Razak - Al-Faris 2002, Halicioglu 2007) and (Amusa et al. 2009). A recent single cointegration approach, known as autoregressive distributed lag (ARDL) of' Pesaran et al. (2001).An ARDL representation of Eq. (1) is formulated as follows:

$$\Delta lnCo_t = \propto_0 + \sum_{i=1}^{m} \propto_{1i} \Delta lnCo_{t-i} + \sum_{i=0}^{m} \propto_{2i} \Delta lnY_{t-i} + \sum_{i=0}^{m} \propto_{3i} \Delta lnP_{t-i} + \sum_{i=0}^{m} \propto_{4i} \Delta D_{t-i} + \propto_5 lnCo_{t-1} + \propto_6 lnY_{t-1} + \propto_7 lnP_{t-1} + \propto_8 D_{t-1} + v_t \quad (2)$$

Once a long-run relationship has been established, Eq. (2) is estimated using an appropriate lag selection criterion. At the second stage of the ARDL cointegration procedure, it is also possible to perform a parameter stability test for the selected ARDL representation of the error-correction model Halicioglu (2007).

A general error – correction model (ECM) of Eq. (2) is formulated as follows:

$$\Delta lnCo_t = \propto_0 + \sum_{i=1}^{m} \propto_{1i} \Delta lnCo_{t-i} + \sum_{i=0}^{m} \propto_{2i} \Delta lnY_{t-i} + \sum_{i=0}^{m} \propto_{3i} \Delta lnP_{t-i} + \sum_{i=0}^{m} \propto_{4i} \Delta D_{t-i} + \lambda \mathrm{EC}_{t-1} + \mu_t \quad (3)$$

Where λ is the speed of adjustment parameter and EC_{t-1} is the residuals that are obtained from the estimated cointegration model of Eq. (1).

The Granger representation theorem suggests that there will be Granger causality in at least one direction if there exists a cointegration relationship among the variables in Eq. (1), providing that they are integrated order of one. Engle and Granger (1987) cautions that the Granger causality test, which is conducted in the first-differences variables by means of a vector autoregression (VAR), will be misleading in the presence of cointegration. Therefore, an inclusion of an additional variable to the VAR system, such as the error-correction term would help us to capture the long-run relationship. To this end, an augmented form of the Granger causality test involving the error-correction term is formulated in a multivariate *p*th order vector error-correction model (Halicioglu 2007).

$$\begin{bmatrix}\Delta lnCo_t\\ \Delta lnY_t\\ \Delta lnP_t\\ \Delta D_t\end{bmatrix}=\begin{bmatrix}C_1\\ C_2\\ C_3\\ C_4\end{bmatrix}+\begin{bmatrix}d_{11i}d_{12i}d_{13i}d_{14i}\\ d_{21i}d_{22i}d_{23i}d_{24i}\\ d_{31i}d_{32i}d_{33i}d_{34i}\\ d_{41i}d_{42i}d_{43i}d_{44i}\end{bmatrix}\begin{bmatrix}\Delta lnCo_{t-i}\\ \Delta lnY_{t-i}\\ \Delta lnP_{t-i}\\ \Delta D_{t-i}\end{bmatrix}+\begin{bmatrix}\lambda_1\\ \lambda_2\\ \lambda_3\\ \lambda_4\end{bmatrix}[EC_{t-1}]+\begin{bmatrix}\omega_{1t}\\ \omega_{2t}\\ \omega_{3t}\\ \omega_{4t}\end{bmatrix} \quad (4)$$

EC_{t-1} is the error–correction term, which is obtained from the long-run relationship described on Eq. (1), and it is not include in Eq. (4) if one finds no cointegration amongst the vector in question.

The existence of a cointegration derived from Eq. (2) does not necessarily imply that the estimated coefficients are stable. Stability tests of Brown et al. (1975), which are also known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests based on the recursive regression residuals, may be employed to that end. These tests also incorporate the short-run dynamics to the long-run through residuals. The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the break points of the model. Provided that the plots of these statistics fall inside the critical bounds of 5% significance, one assumes that the coefficients of a given regression are stable. These tests are usually implemented by means of graphical representation.

4. Data and empirical results

The data used in this paper are annual time series spanning the period 1975-2007. The sources of our data on price of electricity in rials per KWh for agricultural sector were obtained from the TAVANIR information bureau (annual publication)[4]. agricultural electricity consumption in millions of KWh and agricultural added value in milliard rials were obtained from the Iranian central bank[5].

We performed the Augmented Dickey – Fuller (ADF) test and Phillips-Perron (PP) test to verify the exact order of integration of the variables. Table 1 below displays the results of ADF tests and Table 2 below displays the results of PP tests. Results show that all variables used in our study are an I(1) in 1% level of critical values.

4 . TAVANIR is depended on Iranian power ministry. For details see http://www.tavanir.org.ir

5 . For details see http://www.cbi.ir

Table 1. ADF tests

Level		*p*- value	1 st Differences		*p*- value	Order of Integration
Variable	**ADF stat.**		**Variable**	**ADF stat.**		
Co	-1.99	0.28	ΔCo	-4.63	0.00	I(1)
Pr	-0.24	0.92	ΔPr	-5.43	0.00	I(1)
Ad	-2.88	0.18	ΔAd	-7.77	0.00	I(1)

Source: own creation

Note: ADF stands for the Augmented Dickey – Fuller test. All level variables are in logs. Δ is the first difference operator.

Table 2. PP tests

Level		*p*- value	1 st Differences		*p*- value	Order of Integration
Variable	**ADF stat.**		**Variable**	**ADF stat.**		
Co	-1.98	0.29	ΔCo	-4.62	0.00	I(1)
Pr	-2.43	0.35	ΔPr	-5.43	0.00	I(1)
Ad	-2.9	0.17	ΔAd	-7.75	0.00	I(1)

Source: own creation

Note: PP stands for the Phillips-Perron test. All level variables are in logs. Δ is the first difference operator.

Having estimated Eq. (2) by means of OLS, the ARDL approach to cointegration requires the testing of the following null hypothesis : α_5 to $\alpha_8 = 0$ against the alternative that at least one of these coefficients is different from zero. We performed the two-step method of Engle and Granger to verify the cointegration of the regression. Engle - Granger (1987) proposed a two-step method of testing for cointegration which looks for a unit root in the residuals of a first-stage regression. Results indicated that if appoint optimum lag based on Akaike Information Criterion (AIC), optimum lag equal zero and this lag test statistics is -5.61 that greater than 95% critical value for the Dickey-Fuller statistic (-4.93) therefore cointegration relationship matter and existence the long-run equilibrium. Moreover We could appoint optimum lag based on Schwarz Bayesian Criterion (SBC) and Hannan-Quinn Criterion (HQC) that same result will occur (see Table 3).

Table 3. Bounds testing for cointegration

	Test statistic	**LL**	**AIC**	**SBC**	**HQC**
DF	-5.61	27.97	26.97	26.3	26.76
ADF(1)	-3.79	27.97	25.97	24.63	25.56
ADF(2)	-3.02	27.97	24.97	22.97	24.36

Source: own creation
95 % Critical value for the Dickey-Fuller statistic = -4.9327
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Taking for granted the existence of a long-run equilibrium, we estimated by setting the maximum lag-length to two and using the Schwarz Bayesian Criterion (SBC) for the selection of model's lag order. The specification finally selected was the ARDL (1,0,0,0). The derived long-run elasticities resulting shown in Table 4 and diagnostic tests for the ARDL model are shown in Table 5. The estimated elasticities display the expected signs which are negative for the price of electricity and positive for the added value and drought variable and moreover all long-run elasticities are significant. Result show that long-run price elasticity is -0.49 that mean if agricultural electricity price increase ten percent decrease the agricultural electricity consumption 4.9 percent and long-run income elasticity is 2.07 that mean if added value in agricultural sector increase ten percent, increase electricity consumption 20.7 percent. Moreover result shows that drought in Iran (1988-1989) cause to increase the electricity consumption. Finally, diagnostic tests for the underlying ARDL model verify that the residuals are non-serially correlated, correct functional form, normal, and non-heteroscedastic

Table 4. Long-run coefficient for the ARDL (1, 0, 0, 0) model

Variable	**C**	**Pr**	**Ad**	**D**
Coefficient	-13.49	-0.49	2.07	0.43
t-statistic	-1.87	-2.93***	3.64***	1.76*
p-value	0.07	0.07	0.00	0.09

Source: own creation
Note: The ARDL (1, 0, 0, 0) specification was selected based on the Schwarz Bayesian criterion.
The maximum lag length was set to 2.
D is dummy variable for Drought in Iran (1988-1989)
***and * indicate 1% and 10% levels of significance, respectively.

Table 5. Diagnostic tests of the ARDL model

Variable	t-statistic	p-value
Serial Correlation	0.18	0.67
Functional Form	0.04	0.85
Normality	2	0.35
Heteroscedasticity	0.00	0.95

Source: own creation

The short-run model results are presented in Table 6 below. As expected all short-run elasticities are lower in absolute value than those in the long-run. The short-run price elasticity -0.1 that mean if agricultural electricity price increase hundred percent decrease consumption only ten percent and long-run income elasticity is 0.43 that mean if added value in agricultural sector increase hundred percent electricity consumption will increase 43 percent. The lagged error correction term is statistically significant with the expected negative sign. Diagnostic tests for the short-run ARDL model are shown in Table 7.

Table 6. Error-correction representation results. ΔCo, is the dependent variable

Variable	ΔC	ΔPr	ΔAd	ΔD	EC_{t-1}
Coefficient	-2.82	-0.1	0.43	0.09	-0.21
t-statistic	-1.43	-1.69^{*}	1.96^{**}	1.39^{NS}	-2.48^{**}
p-value	0.16	0.1	0.05	0.17	0.02

Source: own creation

Note: The error-correction term is given by:

EC = Co + 0.49670*Pr - 2.0746* Ad - 0.43639*D + 13.4918*C.

** and * indicate 5% and 10% levels of significance, respectively. NS indicate not significance.

Table 7. Diagnostic statistics

R^2-adjusted	0.2548	**Schwarz criterion**	23.2064
***F*-statistic**	5.223	**Akaike criterion**	26.7913
***DW*-statistic**	2.0875	**RSS**	0.2334

Source: own creation

Note: DW is the Durbin-Watson statistic and RSS is the residual sum of squares

In order to ensure the stability of the long-run parameters of our econometric specification, we applied the CUSUM and the CUSUMQ tests in the residuals of the error-correction. Figs. 1 and 2 below, display the results of CUSUM and CUSUMQ tests, respectively. In both figures the dotted lines represent the critical upper and lower bounds at the 0.05 level of significance. The visual inspection of Figs. 1 and 2 reveals that there is no evidence of parameter instability, since the cumulative sum of the residuals and the cumulative sum of the squared residuals move within the critical bounds.

Figure 3. CUSUM test

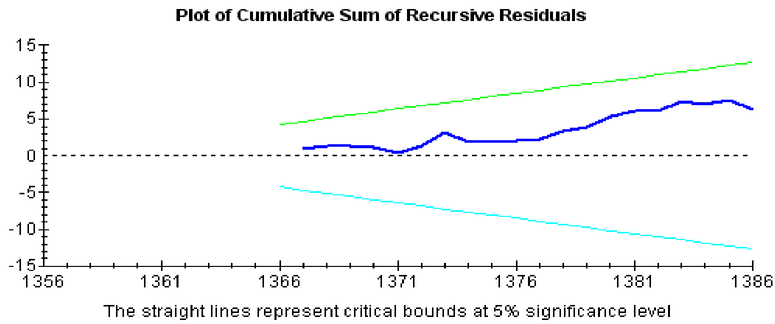
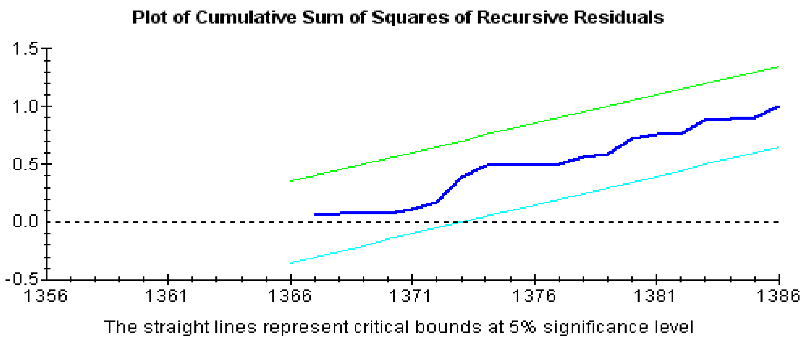


Figure 4. CUSUMQ test



5. Summary and conclusions

This paper has examined the determinants of the agricultural demand for electricity in Iranian economy. The econometric specification assume that the agricultural demand for electricity depends on the price of electricity, added value of agricultural sector and extensive drought that occur in 1988-1989 in Iran. For estimate the model we used advanced ARDL cointegration technique. The error correction model was consistent with the expectations about the signs of the short-run parameters and their magnitude which was found lower than their long-run counterparts. Results show that (1) price and income elasticity in long-run almost 4.9 times price and income elasticity in short-run. (2) low price elasticity lead to low efficiently of price policy then Price liberalization and omitting electricity subsidy is one of the solutions to both increase efficiently of price policy and reduce electricity consumption.

References

Amusa, H. -Amusa, K. - Mabugu, R. 2009: *Aggregate demand for electricity in South Africa: An analysis using the bounds testing approach to cointegration*. Energy Policy, ARTICLE IN PRESS.

Atakhanova, Z. - Howie, P. 2007: *Electricity demand in Kazakhstan*. Energy Policy, 35, 3729–3743. p.

Dergiades, T. - Tsoulfidis, L. 2008: *Estimating residential demand for electricity in theUnited States*. 1965–2006. Energy Economics, 30, 2722–2730. p.

Engle, R. -Granger, C. 1987: *Cointegration and error correction representation: estimation and testing. Econometrica*. 55, 251–276. p.

Filippini, M. - Pachauri, S. 2004: *Elasticities of electricity demand in urban Indian households*. Energy Policy, 32, 429–436. p.

Halicioglu, F. 2007: *Residential electricity demand dynamics in Turkey. Energy Economics*, 29, 199–210. p.

Hondroyiannis, G. 2004: *Estimating residential demand for electricity in Greece*. Energy Economics, 26, 319– 334. p.

Holtedahl, P. - Joutz, F. L. 2004: *Residential electricity demand in Taiwan.* Energy Economics, 26, 201–224. p.

Iranian central bank http://tsd.cbi.ir/IntTSD/Display/Display.aspx

Iranian energy ministry. Annual report, 2007. Available at: http://iranenergy.org.ir/statistic%20info/-energy%20balance/86/chapter04-Electricity.pdf

Iranian energy ministry, TAVANIR. Available at: http://www.tavanir.org.ir

Kumar, B. – Shukla, R. M.1999: *Elasticities of electricity demand in India*. Energy Policy, 27, 137-146. p.

Narayan, P.K. - Smyth, S. 2005: *The residential demand for electricity in Australia: an application of the bounds testing approach to cointegration*. Energy Policy, 33, 467–474. p.

Pesaran, M.H. - Shin, Y. - Smith, R.J. 2001: *Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics* 16/3, 289–326. p.

Razak, F. - Al-Faris 2002: *The demand for electricity in the GCC countries*. Energy Policy, 30, 117–124. p.

Zachariadis, T. - Pashourtidou, N. 2007: *An empirical analysis of electricity consumption in Cyprus*. Energy Economics, 29, 183–198. p.