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Estimating of Electricity Demand of Agricultural Sector in Iran by Cointegration Method

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Abstract

Using time-series data and cointegration techniques in econometrics, particularly Autoregressive Distributed Lag (ARDL) and error correction mechanism (ECM), the study estimated the long-term and short-term relationships of the electricity demand model in Iran's agricultural sector. According to the results obtained, the inelasticity of electricity demand relative to price, obtained in other studies in Iran and other countries, was confirmed in this study too. The absolute value of price elasticity of agricultural demand was 0.521 stating that one percent increase in the price of electricity, its demand decreases by 0.521%. Thus, electricity in the agricultural sector in Iran is a less elastic commodity, as electricity is cheaper than other petroleum products with high economic efficiency and it is less possible to replace it with other products. With the increase in the price of this carrier, the demand for it does not decrease significantly, which shows that the agricultural sector depends on electricity. Moreover, other energy sources cannot be a suitable alternative to it. The findings indicate that all coefficients are significant at the level of five and ten percent. Using time-series data and electricity consumption statistics from 1976 to 2016 and cointegration techniques in econometrics, especially ARDL and ECM, the study estimated the long-term and short-term relationships model of electricity demand in the agricultural sector until 2025.

Keywords: Agricultural Sector, electricity demand, energy carrier price, elasticity of agricultural demand, error correction mechanism, ARDL method

1. Introduction

Considering the increasing tendency of communities to use electrical appliances in all aspects of life, electricity consumption is increasing so fast, so that despite many efforts to reduce electricity consumption, the demand and growth rate of electricity consumption is increasing every day. Hence, electricity as a development engine has managed to have a key role in the economic, social, and cultural development of countries. As electricity has a wide variety of applications, especially in the industrial sector, a country must be able to produce more electricity or at least direct the consumption of this type of energy to optimal consumption if a country wants to increase its economic growth rate. Thus, the relationship between electricity production and consumption with growth and ultimately economic development can be considered a significant and unavoidable relationship.

The need for electricity in the agricultural sector is undeniable and critical. Providing stable, cheap, and optimal electricity could have a very effective role in the process of growth, development, and prosperity of any country. Hence, recognizing the demand for electricity in this sector cannot just present a clear horizon for policymakers and producers of electricity in the country, but can help reach the goals stated in the process of growth and development in the country and in particular the agricultural sector.

Energy demand econometric models extend the regularity of the relationships between model variables to the future. Hence, using these models calls for stability in the behavior of energy consumers and the availability of a large number of historical observations. However, technical-economic models do not rely much on historical time series and depend more on orientations, policies, and strategies designed by policymakers in the energy sector and other sectors of the economy. To estimate the power demand function in this study, we turn to the ARDL method to provide long-term and short-term relationships of the power demand function to gain ECM for the demand of this energy carrier.

2. Theoretical Foundations

Input demand functions could be derived from two methods: deriving the profit function from the inputs or deriving from the cost function relative to the price of each input. In the first method, the direct demand function is obtained and in the second, the indirect (conditional) demand functions for the inputs. In most studies, the second method has been used to derive input demand functions. In this method, first, a production function is selected and its twin cost function is determined, then by deriving the cost function relative to the price of each input, the demand functions are obtained. The results of both methods show that firms' demand for the input relies on the price of the input and the price of other inputs, the product price, or the value of the product produced.

If the profit function is as follows:

$$\pi = pf(x_1, x_2) - r_1x_1 - r_2x_2 - b \qquad (1)$$

Thus, profit is a function of x_1 and x_2 and is maximized regarding these variables. If we take a partial derivative of the above function concerning x_1 and x_2 and equate the obtained expressions to zero, we will have:

$$\frac{\partial\pi}{\partial x_1} = pf_1 - r_1 = 0 \qquad (2)$$

$$\frac{\partial\pi}{\partial x_2} = pf_2 - r_2 = 0 \qquad (3)$$

If we move the price sentence to the right, we will have:

$$pf_1 = r_1\ , pf_2 = r_2 \qquad (4)$$

Partial derivatives of the production function relative to inputs are inputs MP. The final output value of x_1 (pf_1) is the rate at which producing more x1 increases the producer's income. The basic conditions for maximizing profit realize that each input is used to the extent that the value of its final output is the factor of production equal to its price. The producer can increase his profit as long as the income from using an additional unit of input exceeds its cost (Henderson and Quandt, 2008: 173).

Assume that the indifference curve of production is specified from equation q0 = f (x1, x2) and the initial condition for minimizing the cost for this value of production is $\frac{dx_2}{dx_1} = \frac{r_1}{r_2}$. We solve the above equations for the input functions.

$$x_1 = \psi_1(\frac{r_1}{r_2}, q^0) \qquad (5)$$

$$x_2 = \psi_2(\frac{r_1}{r_2}, q^0) \qquad (6)$$

In the above functions, x_1 and x_2 are the minimum cost values considered as functions of the ratio of input prices and production levels. Now, given the initial conditions ri = λfi, we differentiate from the cost function C = r1x1 + r2x2 .

$$\frac{\partial c}{\partial r_i} = x_i + \lambda(f_1\frac{\partial\psi_1}{\partial r_i} + f_2\frac{\partial\psi_2}{\partial r_i}) = x_i > 0 \quad i = 1.2 \qquad (7)$$

In the above equation, λ is the Lagrangian coefficient about minimizing the cost because of the production limit. In the above equation, the sentence in parentheses along the indifference curve is $\frac{\partial q^0}{\partial \mathrm{r_i}} = 0$. Equation (5-18) is called "Lam Sheffard". Partial derivatives of the cost function, given that the price of inputs is equal to the values of the minimum cost of inputs, are:

$$\frac{\partial c(q_1,r_1r_2)}{\partial r_1} = x_1, \frac{\partial c(q_1,r_1r_2)}{\partial r_2} = x_2 \qquad (8)$$

As the cost function variable is a homogeneous function is a first degree relative to the price of inputs, the partial derivatives of that function are zero degrees homogeneous to the price of inputs and depend on the ratio of the price of inputs to the absolute price of inputs. Under the right conditions, the two equations can be solved for the two variables q and $\frac{r_2}{r_1}$ by finding the solution for q we will reach the desired production function (Henderson and Quandt, 2008: 118).

The demand for various forms of energy carriers in various production sectors as a production input is derived from the production function based on the microeconomic theory. For instance, the production function of a particular firm at a given time is defined as follows:

$$Q = F(K, L, M, E_1, E_2, \ldots., E_n, T) \qquad (9)$$

Here, K, L, M, respectively, show the inputs of raw materials, labor, and capital and E_i is the i-th type of energy, including electrical energy, and T is a set of other elements such as technological changes. An enterprise selects the required input combination so that the firm has the least possible cost to produce a certain value of the product. By minimizing the firm cost function, the demand function for the factors of production is obtained. If the demand for electricity as a factor of production is considered as follows:

$$X_{ei} = X_{ei}(P_k, P_1, P_m, P_i, Q, T) \qquad (10)$$

Thus, the electricity demand function at time t is a function of the price of electricity (P_i) and other alternative energies, the price of non-energy inputs (P_m, P_l, P_k), and production or value-added (Q). In this case, other factors such as technological changes (T) may be used. One of the proposed models regarding electricity demand is Bandaranaike and Munasinghe (1983) model where it has been tried to propose a complete model for electricity demand and is the theoretical base of this study.

In this model, supposing that an enterprise consumes electricity and other factors of production, its production function is defined as follows:

$$Q = Q(J, N) \qquad (11)$$

Here, N is the energy consumed, such as electrical energy (E) and other alternative energy (S), and J is the other factor of production. The cost function of the firm is seen as follows:

$$C = P_j J + P_s S + P_e E \qquad (12)$$

The problem of producer optimization calls for minimizing the cost function at a certain level of production. Thus, using the Lagrange function we will have:

$$L = P_j J + P_s S + P_e E + \infty(Q - Q(J, N(E, S))) \qquad (13)$$

Here, P_e is the price of electrical energy services, P_s is the price of alternative energy services, P_J is the price of other production inputs, and μ is the Lagrange coefficient. According to the first-order conditions and derivation of the desired function, we will have:

$$\frac{\partial L}{\partial J} = P_J - \propto \left(\frac{\partial Q}{\partial J}\right) = 0 \implies P_J = \propto \left(\frac{\partial Q}{\partial J}\right) \implies \frac{1}{\propto} = \frac{\frac{\partial Q}{\partial J}}{P_J}$$

$$\frac{\partial L}{\partial E} = P_e - \propto \left(\frac{\partial Q}{\partial N} \cdot \frac{\partial N}{\partial E}\right) = 0 \implies \frac{1}{\propto} = \frac{(\frac{\partial Q}{\partial N} \cdot \frac{\partial N}{\partial E})}{P_e}$$

$$\frac{\partial L}{\partial E} = P_e - \propto \left(\frac{\partial Q}{\partial N} \cdot \frac{\partial N}{\partial E}\right) = 0 \implies \frac{1}{\propto} = \frac{(\frac{\partial Q}{\partial N} \cdot \frac{\partial N}{\partial E})}{P_e}$$

And finally, we will have:

$$\frac{(\frac{\partial Q}{\partial J})}{P_J} = \frac{\left[(\frac{\partial Q}{\partial N} \cdot \frac{\partial N}{\partial S})\right]}{P_s}$$

$$\frac{(\frac{\partial N}{\partial S})}{(\frac{\partial N}{\partial E})} = \frac{P_s}{P_e}$$

Now, if the form of the production function is considered as Cobb–Douglas:

$$Q = J^{f1} N^{f2}$$

So that (($N = \exp\,(E^{g2} S^{g1})$)

and f1, f2, g1, g2 are the indices.

Now, if the Lagrange function is rewritten to minimize the firm cost as follows:

$$L = P_j J + P_s S + P_e E + \propto (\bar{Q} - Q(J, N(E, S))) \quad (14)$$

$$L = P_j J + P_s S + P_e E + \propto (\bar{Q} - J^{f1} \exp(f_2 S^{g1} E^{g2})) \quad (15)$$

By deriving from the above equation in terms of values J, S, E, and index μ, we will have:

$$\frac{\partial L}{\partial J} = P_j - \infty f_1 J^{f1-1} e^{f2S^{g1}E^{g2}} = 0$$

$$\frac{\partial L}{\partial S} = P_s - \infty J^{f1} f_2 g_1 S^{g1-1} E^{g2} e^{f2S^{g1}E^{g2}} = 0$$

$$\frac{\partial L}{\partial E} = P_e - \infty J^{f1} f_2 g_1 S^{g1-1} E^{g2} e^{f2S^{g1}E^{g2}} = 0$$

$$\frac{\partial L}{\partial \propto} = \bar{Q} - J^{f1} e^{f2s^{g1}E^{g2}} = 0$$

By obtaining the values of J, S, E from the above equations and establishing the optimization conditions, finally, the demand function for electrical energy is obtained as follows:

$$E = KP_s\gamma 1 P_e^{\gamma 2} p_J J^{\gamma 3} \quad (16)$$

Here, J = V$_i$ P$_J$ and V$_i$ express the added value and the values, γ2, γ3 K, γ1 are as follows:

$$K = \left(\frac{f_1 + f_2}{f_1}\right)\left(\frac{f_1 g_2^{g_1^{-1}}}{f_1}\right)^{\frac{1}{g1+g2-1}}$$

$$\gamma_1 = \frac{g_1}{g1 + g2 - 1}$$

$$\gamma_2 = \frac{1 - g_1}{g1 + g2 - 1}$$

$$\gamma_2 = \frac{-1}{g1 + g2 - 1}$$

Thus, the electricity demand function is obtained as follows in the end:

$$E = KP_s^{\gamma 1} p_e^{\gamma 2} V_i^{\gamma 3} \quad (17)$$

Moreover, its logarithmic form is presented as follows:

$$LOGE = LOGK + \gamma_1 LOGP_s + \gamma_2 LOGP_e + \gamma_3 LOGV_i \quad (18)$$

The model used in this study for the demand for electricity in the agricultural sector is the same as above.

3. Literature Review

3.1 Foreign Studies

Several studies have been carried out on electricity demand, estimating demand function and its role in economic growth in various countries and to avoid prolonging the issue, a summary of foreign studies conducted, their methods, and results are stated in the Table 1.

Table 1. International literature review

Foreign studies			
Title	**Methodology**	**Results**	**Year**
Houthakker, H. S, demand for home electricity in 42 UK cities	Minimum squares, cross-sectional data	The price elasticity of electricity demand is low and the revenue elasticity of electricity demand is high.	1951
Fisher, F.M., Kaysen, C, electricity demand in the US	Ordinary Least Squares (OLS)	Inelastic demand, the price of electricity does not affect its consumption	1962
Anderson, K.P, a function of electricity demand for 50 US states	Ols	Electricity consumption is less than the changes in the price of electricity and less than the changes in income with elasticity.	1973
McCannan et al., Demand domestic electricity demand for the Northeastern United States	Ols	The cross-price elasticity between gas and electricity is negligible	1977
Ang, B, electricity demand for four Southeast Asian countries (Thailand, Malaysia, Taiwan, and Singapore)	Electricity demand is a function of GDP per capita, price, and per capita consumption	The inelasticity of demand to price changes both in the short and long term	1988
Eltony, M., Nagy, H. and Yousuf, M Electricity Demand in the GCC Countries	Least-squares	The elasticity of electricity demand relative to its price as well as short- and long-term revenue	1993

Bentzen, J., Engsted, T, Angstadt demand electricity in Denmark	Same convergence method and ECM	Long-term is elastic to changes in income but less elastic to changes in electricity prices.	1993
E. Arsenault, J. Bernard, C. Carr, and E. Genest-laplante,, Domestic Electricity Demand for Quebec, Canada	Ols	The demand for electricity in the home sector in the short and long term is unbearable relative to electricity price.	1995
Eltony, M, Electricity demand in Kuwait	Linear error correction	The electricity demand function is a function of electricity price and real per capita GDP	1996
Al-Aziz, A. and Hawdan, D, Electricity demand in Jordan	Stock-Watson Dynamic Demand Modeling Method	Inelasticity to price and income	1999
Ettestol, n, Electricity Demand in the Home Sector in Norway	Linear error correction,	Inelastic price, elastic income	2002
Anderson and Dumsgaard, demand for electricity in the home sector in Sweden	Cointegration	Inelasticity relative to price and income	2002
Yumurtaci, Z. & Asmaz, E, Electricity Demand in Turkey	Vector autoregression (VAR) method	Inelasticity relative to price and income	2004
Morales-Acevedo, Electricity Demand for Mexico	Cointegration	Inelasticity relative to price and income	2014
Cahyo, B.N., Setiawan, A.A., Wilopo,	Prediction according to	The electricity demand function is a function of energy price and production capacity	2018

W. and Musyafiq, A.A., Energy Supply, and Demand Based on Electricity Consumption and Production Capacity, Indonesia	consumption intensity		
Johncourt is growing global electricity demand	Dynamic demand modeling	Electricity efficiency has been declining around the world	2019
Turkekul and Unakıtan	Electricity demand in the agricultural sector	Price elasticity and long-term revenue of electricity in the agricultural sector in Turkey are, respectively, 0.19 and 0.72	2011

3.2 Domestic Studies

Domestic studies carried out on electricity demand, its study and analysis, and its role and its effects on economic growth are presented as the summary of domestic studies, methods, and their results in the Table 2 to prevent prolongation of the discussion.

Table 2. National literature review

Domestic studies			
Title	**Methodology**	**Results**	**Year**
Fakhraei, demand for electricity in the home sector	Time-series,	The electricity consumption is inelastic relative to electricity price	1992
Hosseini Nejadian Koushaki, Electricity Demand, Home Sector, Isfahan	Least squares,	Electricity demand is inelastic relative to price and income in the short run and elastic in the long run relative to elastic income and non-elastic relative to the price	1993
Fathollahzadeh Aghdam, Demand for Electricity in the Home Sector in Iran	Ols	The electricity demand is inelastic relative to price and income, and the revenue elasticity is always greater than the price elasticity.	1993
Kazemi, Per capita consumption of electricity in the domestic sector in Iran	Ols	The demand for electricity in the home sector is proportional to the price of electricity and inelastic income.	1996
Qods, demand for electricity in the home sector	Ols	Inelasticity of the demand for electricity relative to its price in the short and long rung and being elastic to revenue in the long run	1996

Mosalipour, Factors Affecting Electricity Demand in Khorasan	Examining the inelasticity of demand	The elasticity of electricity to price and revenue in the short term	1997
Tavakoli and Bahraini, Electricity demand in Isfahan	General Least Squares (GLS)	Inelasticity is a function of electricity demand relative to price and revenue. The revenue elasticity of electricity demand is greater than its price elasticity	1998
Emami Meybodi, Per capita demand for household electricity in Iran	Granger parasite error correction,	Income elasticity is less than price elasticity and both are less than one	1999
Aminifard, demand for electricity in the home sector	Johansson Convergence	Price elasticity and income less than one	2002
Azerbaijani et al., A function of electricity demand in the country's industrial sector	ARDL	The electricity demand is inelastic relative to price and income, and income elasticity is always from inelastic demand. Short-term price crossover confirms the substitution relationship between electricity and natural gas carriers	2006
Satisfaction and purpose, modeling of electricity demand in the country	Dynamic system approach	Population growth rate and GDP are among the real factors affecting electricity demand	2009
Jalaee et al., Estimation of Household Demand Function in Iran	Provincial panel data	Electricity consumption in the home sector has been mostly affected by consumption habits	2013
Skilled and partners demand energy demand and economic growth	Composite data F-Lemmer	A significant relationship between energy consumption and economic growth	2013
Lotfalipour et al., Estimation of electricity demand functions in domestic and industrial sectors	Structural Time Series Model (STSM)	Inelasticity of demand in the short and long term	2015
Varhrami and Movahedian, the function of electricity demand in the home sector of selected cities in Tehran province	Dynamic panel	Electricity demand in these sectors is inelastic in terms of price and income in the short and long term	2017
Analysis and modeling of energy demand in the agricultural sector	Translog cost function	Gas oil is more sensitive to price changes than electricity	2015
Nikkhah Jourshari et al., Electricity demand, large industrial consumers	Electricity Demand Management Paper	Tariffs based on load responsiveness will shift the load and reduce electricity consumption	2018

Molaei and Entezar, Factors Affecting Energy Demand in Industry	ARDL	Elastic demand reflects the replacement of fossil fuels and electricity	2019
Mehrabi boshrabadi H, Naghavi S Estimation of Electricity Demand in Agriculture	Vector error correction pattern	The most important factors on energy demand in the agricultural sector are the area under cultivation and energy prices	2011

4. Specifying the Model

4.1 Electricity Demand Function in the Agricultural Sector

LCELA =$\alpha_0 + \alpha_1$ LPELA +α_2 LPE + α_3 LVA +α_4 LPOPA+ε_t (19)

LCELA: Logarithm of Electricity Consumption in Agriculture

LPELA: Logarithm of Electricity Consumption Price in Agriculture

LPE: The price index logarithm of other energies, mainly fossil fuels (intended as a substitute variable for the carrier of electrical energy).

LVA: Value Added Logarithm of Agricultural Sector at Fixed Price in 1997 (Billion)

LPOPA: Logarithm of the number of electricity subscribers in the agricultural sector

α0: The width of the origin of the function

εt: sentence disruptive function

LPE: Energy Price Index Logarithm (intended as a substitute variable for the electricity carrier).

The energy price index (PE) is calculated based on the weighted average price of energy carriers and based on the following equation:

$$PE = \frac{(PB^{*}CB+PNS^{*}CNS^{*}PNK^{*}CNK+PNG^{*}CNG+PGT^{*}CGT+PGM^{*}CGM}{(CB+CNS+CNK+CNG+CGT+CGM)} \quad (20)$$

PB shows the gasoline price index, PNS the kerosene price index, PNK the furnace oil price index, PNG the gas oil price index, PG the natural gas price index and PGM is the liquefied gas price index. The Cs in the above equation show the energy consumption stated.

4.2 Variable Reliability Test

The stationarity test is of the key requirements in estimating economic equations with time-series data. Several methods exist to identify stationarity time series from non-stationarity, the most important of which is the Unit root Dickey-Fuller test and the Augmented Dickey-Fuller Test.

Considering what was stated, we examine the reliability of the proposed model variables based on the Augmented Dickey-Fuller test. As is seen, the null hypothesis that the unit root has time series variables based on McKinnon test statistics is checked in Table 3.

Table 3. Dickey-Fuller test results for electricity demand patterns variables.

Variable (per level or with a one-time difference)	Function form	Statistics observed at the level or with a one-time differentiation	Critical ADF values			Stationary level
			1%	5%	10%	
LCBA	With intercept without trend	-4.92	-4.32	-3.57	-3.22	I (0)
✷DLPBA	With intercept without trend	-4.4	-3.67	-2.96	-2.62	I (1)
LPE	With intercept without trend	-6.87	-3.57	-2.92	-2.59	I (0)
✷DLY	With intercept without trend	-3.25	-3.61	-2.93	-2.60	I (1)

LPOPCO	With intercept without trend	-8.99	-3.60	-2.93	-2.60	I (0)

✷ The letter D at the start of the variable name shows a single difference for the stationarity of the variable.

The stationarity test is one of the key requirements in estimating economic equations with time-series data. A time-series variable is considered stable when the mean, variance, covariance, and correlation coefficients remain constant over time, no matter at what point in time we calculate them.

The stationarity is important as if a time series is not stationary, it will not have the usual statistical properties for the first and second moments of electrical energy, meaning that these moments are not inclined to the society's moments as the sample size increases. This is because the statistics obtained are a function of time and change over time, which disrupts and invalidates the base of the distributions we used for the torques or sample statistics for conventional statistical tests and inferences. The observations of the above table indicate the degree of stationarity or non-stationarity of the variables [I (0) or I (1)] with the help of critical values and the statistics observed with one-time differentiation. It has to be noted that, in the ARDL method, unlike the Johansson multivariate VAR approach, there is no need that all variables be the first-degree stationery so that the variables in the cointegration equation can also be zero-degree stationery.

4.3 Estimating the Electrical Energy Demand Function

To estimate the power demand function in the study, we refer to the ARDL to provide long-term and short-term relationships of the power demand function, to obtain ECM for the demand of this energy carrier, as with ECM, short-term fluctuations of variables can be presented to long-term equilibrium values.

4.4 Estimating Models Using the ARDL and ECM

To use the ARDL and ECM models in estimating models, proper intervals for model variables have to be determined according to the Schwartz-Bayesian criterion. This has been done using MacroFit 4.1 and the results are as follows (Tables 4, 5).

Table 4. Estimating self-explanation pattern coefficients with ARDL using Schwarz-Bayesian criterion.

Variables	Coefficients	T statistic	Standard error
LCBA(-1)	-0.465	-3.84	0.121
LCBA(-2)	-0.016	-0.13	0.123
LCBA(-3)	0.203	2.78	0.073
LPBA	0.032	1.68	0.019
LPBA(-1)	-0.082	-3.28	0.025
LPBA(-2)	0.078	2.78	0.028
LPBA(-3)	-0.074	-3.08	0.024
LPE	0.011	0.47	0.023
LPE(-1)	-0.012	-0.54	0.022
LPE(-2)	0.055	3.43	0.016
LY	0.261	6.52	0.04
LY(-1)	-0.011	-0.13	0.084
LY(-2)	-0.137	-2.01	0.068
LPOPCO	0.332	3.73	0.089
Intercept	-3.26	-3.1	1.051
R-Squared	0.99		
D.W	2.6		

Table 5. Estimating ARDL coefficients with wide intervals using Schwarz-Bayesian criterion.

Regressor	Coefficient	Standard Error
LCELI(-1)	0.71	0.071
LPELI	-0.083	0.038
LPELI(-1)	0.154	0.039
LPE	-0.195	0.062
LPE(-1)	0.161	0.051
LVI	0.419	0.089
LVI(-1)	-0.299	0.092
LPOPI	0.04	0.022
LPOPI(-1)	0.014	0.029
LPOPI(-2)	-0.082	0.028
INPT	-0.549	0.494
R-Squared	0.99	
D.W	1.9	

The tests related to the autocorrelation of the residual terms, cryptographic test, normality, and variance of consistency of waste sentences are placed in the Table 6.

Table 6. Residual terms autocorrelation, cryptographic test, normality, and variance of residual sentence similarity.

Test statistics	LM Version	F Version
A: Serial Correlation	CHSQ(1)=.932231[0760]	F(1,19)=.057309[.813]
B: functional Form	CHSQ(1)=2.1500[0507]	F(1,19)=1.6960[.528]
C: Normality	CHSQ(2)=.08554[0825]	F(1,19)=.065015[.751]
D: Heteroscedasticity	CHSQ(1)=.3297E-3[.986]	F(1,19)=.3084E-3[.986]

Independent variables explain 99% of the changes in the dependent variable, and according to the Durbin-Watson statistic, there is no autocorrelation between the error terms.

Now, after determining the proper intervals according to the Schwarz-Bayesian criterion and examining the redundancy of the model variables, we examine the cumulative relationship between the model variables to ensure the existence of a cumulative relationship between the model variables and the falsity of the estimation equation.

As the obtained statistic is higher than the critical value - (-3.19) - stated by Benarji, Dolado, and Mister (1992), Hypothesis H0 is rejected. Thus, one can conclude a long-run equilibrium relationship between the electricity model variables and the long-term relationship between electricity demand in the agricultural sector is not false.

Now, by ensuring the existence of a long-run equilibrium relationship between the model variables, we estimate the long-term coefficients of the model, shown in the Table 7.

Table 7. Long-term coefficients of electricity demand in the agricultural sector using the ARDL method and the Schwarz-Bayesian criterion.

Dependent variables	**Independent variables**				
LCELA	LPELA	LPE	LVA	LPOPA	Intercept
Coefficient	-0.521	0.076	0.584	1.09	-6.88
Standard Error	0.145	0.043	0.278	0.082	2.48
T-Ratio	3.58	1.78	2.09	13.23	-2.77

As the results show, the research hypotheses stating the effect of electricity demand in the agricultural sector on the price of this carrier, the price index of other energy carriers (as a substitute commodity), the value-added of this sector, and the number of electricity subscribers in the agricultural sector are approved. The following is the long-term demand for electricity in the agricultural sector.

LCELA=-6.88-0.521LPELA+0.076LPE+0.584LVA+1.09LPOPA

Based on the above equation, one can state that the price elasticity of demand is -0.521 showing that with a one percent increase in the price of electricity, the demand decreases by 0.521%; therefore, electrical energy is a less elastic commodity. As electrical energy is cheaper than the other petroleum products and has high economic efficiency, there is less possibility of replacing them with other products, and the demand for it will not decrease significantly with the increase in the price of this carrier, it is seen that the agricultural sector is dependent on electricity and other energy sources cannot be a suitable alternative to it, and the elimination of electricity subsidies in the agricultural sector cannot have much effect on reducing its consumption. However, if this sector is compared with the domestic and industrial sectors, given that the elasticity of demand in this sector is higher, it is expected that with the increase in the price of electricity, its demand in the agricultural sector will decrease more relative to the domestic and industrial sectors. Given the variable coefficient of the price index of other energy carriers considered as a substitute for the variable of electrical energy, the cross-elasticity of demand can be examined. This elasticity is 0.076 and shows that the replacement of this energy carrier is not very important, as, with a one percent increase in the price index of other energy carriers, the demand for electricity increases by less than one percent. However, the revenue elasticity of electricity demand is higher and more effective than the other two elasticities. The numerical value of this elasticity is 0.584 showing that by increasing the value-added of this sector by one percent, the electricity demand can be increased by 0.584%. Thus, one can justify that in the long run, given the high efficiency of electricity in the agricultural sector, the elimination of electricity subsidies and increase in its price will not have much effect on reducing its consumption in the agricultural sector. Moreover, one can state that another reason is the lack of a suitable substitute for electricity in the agricultural sector, and this sector will continue to have electricity as its first option to continue its activities, even if there is an increase in energy prices in this sector.

We now estimate the model using the ECM model to examine the short-term dynamic behavior of the variables and determine the adjustment rate toward the long-run equilibrium between the model variables. The results obtained from model estimation are given in the Table 8.

Table 8. Short-term coefficients of the electricity demand model in the agricultural sector using the ECM method.

Regressor	Coefficient	Standard Error
DLCELA(-1)	0.291	0.109
DLPELA	-0.169	0.092
DLPELA1	0.184	0.098
DLPE	0.204	0.072
DLVA	0.578	0.031
DLVA1	-1.048	0288
DLVA2	0.709	0.274
DLPOPA	0.778	0.109
DLNPT	-4.87	2.3
ECM(-1)	-0.708	0.109
R-Squared	0.82	0.494
D.W	2.076	

As is seen, the error correction factor sentence is significant. The error correction coefficient is estimated as -0.70, showing the relatively low speed of adjustment stating that each year 70% of the imbalance of a period in electricity demand in the agricultural sector or the consumption of electricity in this sector, in the period is adjusted in the next period. In other words, it will take approximately 4 years to fully adjust the results of implementing a policy. In this sector, by implementing demand policies, one cannot reach the desired goals quickly. In other words, the main difference between this sector and industry and the home sector is that changes in electricity demand in this sector in the event of changes in variables such as energy prices to be able to show itself well needs more time and perhaps the reason is the lack of high mobility of industries compared to the other two sectors.

We estimate the model using the error correction model to examine the short-term dynamic behavior of the variables and show the adjustment speed towards the long-run equilibrium between the model variables. The results of the model estimation are given in Table 9.

Table 9. Short-term coefficients of the electricity demand model using the error correction method.

Variables	Coefficients	T statistic	Standard error
DLCBA1	-0.207	-1.66	0.124
DLCBA2	-0.213	-2.76	0.077
DLPBA	0.032	1.68	0.019
DLPBA1	-0.004	-0.19	0.021
DLPBA2	0.073	3.04	0.024
DLPE	0.0109	4.73	0.002
DLPE1	-0.055	-3.43	0.016
DLY	0.261	6.52	0.04
DLY1	0.137	2.01	0.068
DLPOPCO	0.332	3.73	0.089
DINT	-3.26	-3.1	1.051
ECM(-1)	-0.45	-6	0.075
R-Squared	0.935		
D.W	2.31		

As is seen, all coefficients are statistically significant and agree with the sign. Moreover, the error correction factor term is significant. The error correction factor is estimated to be -0.45, showing a relatively high rate of adjustment, and states that each year 45% of the imbalance of one period in electricity demand or electricity consumption is adjusted in the next period.

After estimating the coefficients of the error correction pattern by OLS method, a set of diagnostic tests have been used to evaluate the accuracy and validity of the estimated relationship statistically, which include:

1- Box-Pierce test (1970) based on Q statistic to test the stationarity of the residual terms and observe the correlation of the residual terms.

2- Breusch-Godfrey test (1978) for successive correlation of order K.

3- RESET cryptographic test (1960) for the accuracy of function specification.

4- Jarque-Bera test (1980) for the normal sentence error distribution

5- ARCH test for conditional consecutive autocorrelation.

6- White test for heterogeneity variance

Table 10. The results of a set of diagnostic tests

Type of test	Lags	Test statistic	The area under the curve after the number of test statistics	Test results

Stationarity of error terms by Ljung -box method	1 to 16	Qϵ {0.04 and 10.5}	P=0.48-0.98	Error terms are stationary
Normal distribution of error sentences by Jarque-Bera method	-	X2=0.49	P=0.78	Error terms have a normal distribution
Sequential correlation in error sentences by Breusch-Godfrey method	2	F = 0.05 X2=0.05	P=0.94 P=1	Error terms are not sequentially correlated
Variance heterogeneity by the White method	-	F = 0.51 X2=7.2	P=0.86 P=0.78	Error terms do not have heterogeneity variance
Consecutive heterogeneity variance (ARCH)	1	F = 0.80 X2=0.83	P=0.37 P=0.35	Error terms do not have a conditional heterogeneity variance
Correctly specifying the shape of the pattern by coding	-	F = 2.56 X2=3.31	P=0.12 P=0.07	The shape of the pattern is specified correctly

The above set of tests shows that the estimated short-term dynamic function has no statistical problems and its coefficients are quite reliable (Table 10).

5. Conclusions and Suggestions

According to the findings, the inelasticity of electricity demand relative to price, obtained in other studies in Iran and other countries, was confirmed in this study too. The results show that all coefficients are significant at the level of five and ten percent. The results indicate that electricity is less attractive for the agricultural sector.

Hence, price changes cannot have much effect on demand in this sector and consumption management because the problems in electricity production will not be very successful by implementing pricing policies in the agricultural sector. Considering the output of the model and the elasticity of electricity demand substitution, showing no suitable substitute for electricity in the agricultural sector, one can state that managing electricity consumption in other economic sectors, enhancing production technology in the agricultural sector, efforts to increase production efficiency and time management of consumption during the day and night hours could be suggested solutions in managing electricity consumption in the agricultural sector.

The study findings confirm the effective and indispensable role of electrical energy in this process; thus, decision-makers must put on the agenda providing a stable and affordable electricity supply to increase the production capacity and competitiveness of the sector.

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References

1. Al-Aziz, A. and D. Hawdan (1999): Estimating the Demand for Energy in Jordan: A stock Watson Dynamic OLS (DOLS) Approach", Survey Energy Economics Center, Department of Economics
2. Aminifard, A (2002): The Estimation of Demand for Electricity at Homes in Iran: A Cointegration Approach (1967-1999). MA Thesis (Economics), Shiraz University, Iran. (In Persian)
3. Anderson, B. and N. Damsgaard (2002): Residential Electricity Use –Demand Estimation Usiny Swedish Micro Data, Stockholm School of Economics, Box 6501, S-11383 Stockholm, Sweden.
4. Anderson, K.P (1973): Residential energy use: an econometric analysis, In: The Rand Corporation, Santa Monica, California, EUA
5. Ang, B. (1988): Electricity-output ratio and sectoral electricity use :The case of East and Southeast Asian developing countries". Energy policy 16(2): 115-121.
6. Azarbaijani, K (2006): Electricity Demand Analysis and Estimation in Industrial Sector in Iran", the Journal of Economic Research 73: 133-166
7. Bentzen, J. and T.Engsted, T (1993): Short – and Long-Run Elasticities in Energy Demand: A Cointegration Approach. Energy Economics 15 (1): 9-16
8. Bandaranaike R. and M. Munasinghe (1983): The Demand for Electricity Services and the Quality of Supply. In: The Energy Journal 4 (2): 49-71.
9. Cahyo, B.N., A.A. Setiawan, W. Wilopo and A.A. Musyafiq (2018): Energy Demand and Supply Forecasting Based on Electricity Consumption Intensity and Production Capacity for Development of Operating Support in Headquarter of Indonesian National Army, E3S Web of Conferences 73: 01004, ICENIS 2018.
10. Emami Meibodi, A., T. Mohammadi and S.M.H. Soltanololamaii (1999): An Estimation of Natural Gas Domestic Demand Function by Using Kalman Filter Method (A Case Study of Residential Gas Demand Function in Tehran), Quarterly Journal of Quantitative Economics 7(3), 23-41.
11. Ettestol, N (2002): Estimating Residential Demand for Electricity with Smooth Transition Ragression. NTNU, Trondheim, Norway.
12. Arsenault, E., J. Bernard, C. Carr and E. Genest-laplante (1995): A total energy demand model of Qubec: Forecasting properties, Energy Economics 17: 2.
13. Eltony, M., H. Nagy and M. Yousuf (1993): The Structure of Demand for Electricity in the Persian Gulf Cooperation Council Countries. the Journal of Energy and Development 4P: 213-221.
14. Eltony, M.N. and A. Hoque (1996): A cointegrating relationship in the demand for energy: The case of electricity in Kuwait,' Journal of Energy and Development 21: 293-301.
15. Fakhraei, H (1992): Final Report of Forcasting of Energy Demand in Different Consumed Sectors
16. Fatollahzade, A (1993):The Estimation of Residential Energy, MSc Thesis, Economics Department, Tehran University.
17. Fisher, F.M., C. Kaysen (1962): A Study in Econometrics: The Demand for Electricity in the United States. North-Holland Publishing Co, Amsterdam
18. Ghods, Gh.R (1996): The Estimation of Residential and Business Energy, MSc Thesis, Science & Technology University.
19. Henderson, J.M. and R.E. Quandt (2008): Theory of Microeconomics. Translated by Morteza Gharabaghian and Jamshid Pajouyan. Rasa Publications.
20. Houthakker, H. S (1951): Some calculations of electricity consumption in great Britain, Journal of the Royal Statistical Society
21. Hosseini Nejadian Kushki, R (1993): The Estimation of Residential Electricity Function Isfahan Province, MSc Thesis, Economics Department, Tehran University
22. Jalaee, S.A., S. Jafari and S. Ansari Lari (2013): The Estimation of Electricity Consumption in the Residential Sector in Iran: A Provinces Panel, Iranian Energy Economics Research, 2: 69-92.
23. Kazemi, A (1996): Electricity demand analysis and estimation in household and industrial sectors. MSc thesis, Faculty of Economy, University of Tehran.
24. Mehrabi boshrabadi, H. and S. Naghavi (2011): Estimation of energydemand function in agriculture of Iran. journal of AgriculturalEconomics Researches 3(2): 147-162.

25. Mosallapour, H (1997): Examining Electricity Industry and Estimation of Demand, Production and Cost Functions in Khorasan Province, MSc Thesis, Economics Department, Tehran University.
26. Lotfalipour, M.R., M.A. Fallahi and S. Nazemi Moezabadi (2015): Estimation of electricity demand functions in domestic and industrial sectors of Iran using structural time series model (STSM). In: Iranian Journal of Applied Economic Studies 4 (13): 208-187.
27. Molaei, M. and A.R. Entezar (2019): Factors Affecting Fossil Energy Demand in the Industrial Sector of Iran. In: Quarterly Journal of Applied Economic Studies, Bo Ali Sina University 8 (30): 177-193.
28. Morales-Acevedo, A. (2014): Forecasting future energy demand: Electrical energy in Mexico as an example case. Energy Procedia 57: 782-790.
29. Nikkhah Jourshari, E., R. Effatnejad and M. Hedayati (2018): Management of Electricity Demand by Large Industrial Consumers Using Special Categories and Subcategories. In: Quarterly Journal of Energy Policy and Planning Research 4 (13): 197-227.
30. Tavakoli, A. & J. Bahreini (1998): The Estimation of Residential Demand for Electricity: A Case Study of Isfahan Province, Journal of Economic Research (Tahghighat-E-Eghtesadi), Volume 33, Issue 1, Winter 115-134.
31. Turkekul, B. and G. Unakıtan (2011): A Co-Integration Analysis of the Price and Income Elasticities of Energy Demand in Turkish Agriculture. Energy Policy 39: 2416-2423.
32. Varhrami, V. and M. Movahedian (2017): Fitting the Electricity Demand Function of the Home Sector in Selected Cities of Tehran Province Using the Dynamic Panel Method. Quarterly Journal of Economic Research (Sustainable Growth and Development) 17 (2): 121-144.
33. Yumurtaci, Z. & E. Asmaz, (2004): Electric Energy Demand of Turkey for the Year 2050. Energy Sources 26: 1157–1164