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The Estimation of Energy Demand Function Using Almost Ideal Demand System; Case Study: Energy Demand in the Industrial Sector of Khuzestan Province

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Abstract: Identifying and evaluating the energy consumption pattern of the country, provinces and different economic sectors is the basic problem in the countries. Planning for energy production, consumption and budgeting needs evaluating the consumption pattern via estimating the demands. The purpose of this study is to determine the factors affecting the pattern of energy consumption and to determine the supplement and substitute relationships of energy carriers (petroleum products, natural gas and electricity) and examining the role of energy carriers in the cost of different sectors of the province. For this purpose, the linear approximation of almost ideal demand system in both bound to the theoretical constraints (additively, homogeneity and symmetry) and unbound and ISUR estimation method is used. The time period of this study is 1988-2005 and seasonal. The results show that in the industrial sector, just homogeneity constraint is accepted for petroleum products and also for both natural gas and petroleum products, symmetry constraint is accepted via Wald test .Price elasticity in both states, are negative and smaller than one. In both bound and unbound, cross elasticity of demand for natural gas than electricity does not provide the same results. In other cases, the cross elasticities of demand for energy carriers show lower values and it means that against any change in the price of energy carriers, the consumer of industrial sector cannot show great reaction. Income elasticities in both states, are smaller than one and show that energy carrier is necessary in this sector.

Keywords: Almost Ideal Demand System, Energy Carriers, Price and Income Elasticity

1. INTRODUCTION

The issue of non-renewable resources of energy and the issue of environmental protection are the issues that need the attention of policy makers of energy to optimize utilization of energy resources. Based on the statement from the World Commission on Environment and Development, "the permanent development, is the development that will meet the needs of today, without endangering the ability of future generations in meeting their needs" (Ministry of Economic Affairs and Finance, 1997, p. 18)

Iran, while having about 10 percent of the world's energy reserves and 15 percent of the gas reserves, and because of the proximity to the energy resources of the Caspian Sea and the Persian Gulf and also having access to the international waterways, has a very special and good place for the exchange of energy carriers in the world (Valiei, 2002, P. 92).

Among the provinces of Iran, Khuzestan province has a special status in the country due to the special geographical conditions and economic and political situations. Rivers full of water, oil and gas underground resources and easy access to international waters, have made this province distinct from the other provinces in the country and extensive resources of surface water and groundwater have led huge dams to be built in this province (Water & Electricity Organization of Khuzestan, 2001, P. 8).

Identifying and evaluating the energy consumption pattern in the country, provinces or different economic sectors is a major problem in the economy of the countries. Planning for producing and regulating the energy consumption requires evaluating the consumption pattern via estimation of demand function. non-renewable energies are finite resources and its good economic management, is important; because in addition to this issue that energy is a final good, part of the costs of producing goods and services in various sectors of the economy, is the cost of using different types of energy. This cost, due to the global price of energy is quite remarkable. Energy production and consumption is one of the main economic activities and study and research in the field of energy production and consumption is one of the major research activities in the economy. One of the important aspects in energy research is the energy management. . One of the necessary tools in the field of energy management, is the efficient energy pricing and encouraging energy saving applying price and non-price policies. Applying appropriate policies, needs evaluating and identifying the consumption behavior of consumers in different parts. One of the main methods of this study is to estimate the demand function. Moreover, as large part of the government subsidies is done in the energy sector, studying the demand for energy for optimal allocation of subsidies is necessary among different sectors.

2. RESEARCH LITERATURE

In the 60s, econometric methods were used extensively to estimate the demand for energy. These models applying theories of economics and statistics, began to test the relationship between economic variables empirically (mainly price and income) and demand for energy. Since the parameters of these model are estimated based on historical or cross-sectional data, anticipating the demand for energy with the help of these models, is based on generalizing past conditions to the future. Several factors led to this issue that predictions derived from the application of econometric models do not match the reality. Hence, from the first mid of 70s, models based on technical processes were paid attention more; because these models were able to study the effects of structural and technological changes on the growth of demand for energy. Since the second half of the 80s, this idea was strengthened that the issue of energy modeling should be treated with systematic method; this means that the effects of economic- social variables and effects of the factors, are considered simultaneously in estimating the demand for energy. Some related studies are mentioned here.

Baxter and Reas (1963) have studied the electricity demand for the industrial sector. Their study concluded that combined calculation method cannot be accepted because different types of energy should be converted into equivalent unit. According to their opinion, converting different energies into equivalent unit (eg equivalent of barrels of crude oil) does not consider the fact that different types of energy cannot be converted into equal usable energy.

Ali Askari (2002) has estimated the demand for electricity in the domestic sector using pooling data among 16 regional electricity companies during the period 1995-1999 as follows.

Shams, Kimiagar and Paknezhad (2002) have investigated the pattern of demand for fuel oil in the country. Using fuel Oil, real price of fuel oil and GDP per capita are the variables under the study in this research. In this study, using Johanson and Juselius Method, and long-term and co-integration relationship among the variables mentioned above, finally the error correction model was estimated. Based on the results of this research, in the long-term period, the effect of per capita income on demand for fuel oil is positive, but it is not significant, while the effect of real price of fuel oil on its demand in the long-term period, is negative and significant that this issue confirms the effectiveness of the price adjustments of this product on its consumption.

Labandrya, Labygar and Rodriguez (2005) have evaluated the demand for energy carriers in Spain for two time periods, 1973-74 and 1980-81 in systematic method. Energy carriers under study in this research are electricity, natural gas, LPG and fuel related to private cars. In this system, the demand for public transport and food which is in relation to the household consumption has also been considered. The price elasticity obtained from the estimation of energy carriers show that consuming energy carriers in Spain is inelastic with respect to their price. Price elasticity of energy carriers for electricity is 0.80, for natural gas is -0.047, for LPG is -0.367 and for fuel car is -0.106. These coefficients indicate that the electricity has the highest price elasticity and natural gas, has the lowest price elasticity.

Halafi and Eghbali (2006) have estimated the demand long-term functions for domestic and industrial electricity of Khuzestan province for the period 1961-2001 using the autoregressive distributed lag (ARDL) approach. The results showed that for both demand functions for domestic and industrial electricity of Khuzestan province and in two general and per capita shapes, long-term and stable functions can be extracted.

Kerporns (2006) has investigated the demand for food and drink, energy and other commodities for Thailand using almost ideal demand system. Energy used in this study contains petroleum products (Gasoline 91, Gasoline 95 and fuel oil), electricity and natural gas. The time period of this research is 1993-2005 and it is seasonal.

3. RESEARCH METHODOLOGY

The method of this research is multiple correlation and studying the causal relationship between the demand for energy carriers and its determinants using existing information. Demand estimation for energy carriers needs to detect the relationship between demand (consumption) for energy carriers and factors affecting these elements.

3-1. almost ideal demand system

Almost ideal demand system (AIDS) is a system in which demand equations are extracted from a consumer expenditure function in the shape of PIGLOG (Price Independent Generalized Liner Logaritm). Deaton and Muelbauer have presented (PIGLOG) function as follows.

$$Lne(u,p)=(1-u)ln\left[a(p)\right]+(u)\,ln\left[b(p)\right] \quad (1)$$

In this relation, it is assumed that the consumer utility (u) is between zero and one. Utility zero indicates the living in low level and utility one indicates maximum pleasure of life. a (p) represents the necessary expenditure to achieve the zero utility level or subsistence costs and b(p) shows the necessary costs to achieve the one utility level or welfare cost, which are defined as follows.

$$Lna(p)= a_0+\sum_k a_k\, ln\, p_k + \frac{1}{2}\sum_k\sum_j \gamma^*_{kj}\, ln\, p_k\, ln\, p_j \quad (2)$$

$$Lnb(p)=lna(p)+\beta_0\prod_k p_k^{\beta_k} \quad (3)$$

Therefore, the relationship between ALDS costs can be provided as follows:

$$Lne(u,p)= a_0+\sum_k a_k\, ln\, p_k + \frac{1}{2}\sum_k\sum_j \gamma^*_{kj}\, ln\, p_k\, ln\, p_j + u\,\beta_0\prod_k p_k^{\beta} \quad (4)$$

u is the level of utility, and a_i ، β_i و γ^*_{ij} are parameters. It can be showed that $e(u,p)$ in terms of p is linear homogeneous if the following constraints are true.

$$\sum_i \alpha_i = 1$$

$$\sum_j \gamma^*_{kj} = \sum_k \gamma^*_{kj} = \sum_j \beta_j = 0 \quad (5)$$

Using Shepherds Lemma, the demand for various goods can be derived from $e(u,p)$ function.

Based on Shepherds Lemma q_i is achieved as follows.

$$\frac{\partial e(u,p)}{\partial p_i} = q_i \quad (6)$$

If both sides of the above equation are multiplied by the $\frac{p_i}{e(u,p)}$, we have:

$$\frac{\partial \ln e(u,p)}{\partial \ln p_i} = \frac{p_i q_i}{e(u,p)} = w_i \quad (7)$$

In which w_i is the budget share of i th commodity. Therefore, if the logarithmic equation (4) is derived, w_i is achieved as the following equation.

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i u \beta_0 \prod p_k^{\beta_k} \quad (8)$$

From the perspective of maximum utility consumer, total expenditure of m is equal to $e(u,p)$. This equality, gives u as a function of p and m which means an indirect utility function. If this is done for function (1) and is placed at 8, then the expenditure share of i th commodity will be achieved as a function of p and m.

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{m}{p}\right] \quad (9)$$

If in the above equation, we obtain $\ln p$ in terms of other values, the following equation is obtained.

$$LnP = a_o + \sum_k a_k \ln p_k + \frac{1}{2}\sum_j \sum_k \gamma_{kj} \ln p_k \ln p_j \quad (10)$$

This system is called the almost ideal demand system in the shape of budget share. In this system, the homogeneity, additivity and symmetry properties must come true, these properties are defined as follows.

$$\sum_{i=1}^{n} \alpha_i = 1, \quad \sum_i \gamma_{ij} = 0 \quad , \sum_i \beta_i = 0 \qquad \text{Additive property (11)}$$

$$\sum_j \gamma_{ij} = 0 \qquad \text{Homogeneity (12)}$$

$$\gamma_{ij} = \gamma_{ji} \qquad \text{Symmetry (13)}$$

In estimation, if the mentioned constraints do not apply, the system should be estimated in the shape of not being bound by the constraints.

System of (AIDS) equations is easily interpreted. Based on this system, if the relative prices and real incomes (real expenditure) do not change, the share of expenditure of the mentioned commodity, will stay constant. Any changes in the real expenditures via β_i s and any changes in the relative prices via α_i s influence on the expenditure share of goods. β_i s for luxury goods are positive and for necessary goods are negative and the sum of them is zero. System of (AIDS) equations can be generalized to the entire population (Deaton and Muelbauer, 1980).

The important point in the AIDS system is that this system is based on nonlinear coefficients according to the p price index. Thus, in the nonlinear almost ideal demand system (NAIDS), the coefficients of the variables should be estimated using nonlinear methods. In most empirical studies, rather than using the p real index and non-linear method, Stone's index is used as a substitute for the p real index. With this replacement, the model is changed to linear almost ideal demand system and demand functions are defined as linear functions of prices and total expenditure which can be estimated using linear methods. Deaton and Muelbauer (1980) have used Stone's index to transform a nonlinear demand system into a linear system, as follows.

$$LnP=\sum_k w_k \ln P_k \quad (14)$$

In this system, the income elasticity, own-price elasticity and cross price elasticity are calculated as follows.

$$\eta_i = \frac{\beta_i}{w_i} + 1 \quad (15)$$

$$\mu_{ii} = \frac{\gamma_{ii}}{w_i} - 1 - \beta_i \quad (16)$$

$$\mu_{ii} = \frac{\gamma_{ij}}{w_i} - \beta_i \left(\frac{w_j}{w_i} \right) \quad (17)$$

3-2. introducing variables and explicating the model

Statistical data used to estimate the demand function for energy carriers in the industrial sector of the Khuzestan province, is the seasonal information related to 1999-2005. Variables used in the estimation equations are: E variable that indicates the power consumption (kWh), G natural gas (cubic meters) and O petroleum products (barrel of crude oil equivalent), PE is the average of nominal price of electricity sales (RLS kilowatt-hours), PO is the average of nominal price of petroleum products (RLS barrel of crude oil equivalent), PG is the average of nominal price of natural gas (RLS cubic meters) and PT is the price of other goods.

For prices of other commodities, retail quarterly price index based on 1990 is used. Due to lack of sufficient data, instead of expenditure variable, the value added of this sector (X) is used as a substitute variable. For the quarterly added value, Diz method and MATLAB software are used. In the system under study, the consumption of other goods is also considered as a separate item to make the demand system under study comprehensive. We show the proportion of electricity consumption out of total expenditures with WE, the proportion of natural gas out of total expenditures is shown with WG, the proportion of petroleum products out of total expenditures is shown with WO, the proportion of using other goods out of total expenditures is shown with WT. In order to realize the price of energy carriers, inflation rate is used. Furthermore, in order to realize the expenditure of each part, Stone's index is used as E=X/P. L_n at the beginning of each variable's name refers to the natural logarithm of that variable. Due to the above mentioned variables, approximation model of almost ideal demand system for the aforementioned goods in these parts are as follows.

$$\begin{cases} WE = \alpha_{10} + \gamma_{11} LnPEr + \gamma_{12} LnPGr + \gamma_{13} LnPOr + \gamma_{14} LnPT + \beta_1 Ln\left(\frac{X_i}{P^*}\right) + U_1 \\ WG = \alpha_{20} + \gamma_{21} LnPEr + \gamma_{22} LnPGr + \gamma_{23} LnPOr + \gamma_{24} LnPT + \beta_2 Ln\left(\frac{X_i}{P^*}\right) + U_2 \\ WO = \alpha_{30} + \gamma_{31} LnPEr + \gamma_{32} LnPGr + \gamma_{33} LnPOr + \gamma_{34} LnPT + \beta_3 Ln\left(\frac{X_i}{P^*}\right) + U_3 \\ WT = \alpha_{40} + \gamma_{41} LnPEr + \gamma_{42} LnPGr + \gamma_{43} LnPOr + \gamma_{44} LnPT + \beta_4 Ln\left(\frac{X_i}{P^*}\right) + U_4 \end{cases} \quad (18)$$

In this system, we have $Lnp^* = \sum_{ki=1}^{4} w_{ki} Lnp_{ki}$ .Because additivity constraint is imposed on the model, one of the system equations will be deleted at the time of estimating unbound form of the equation and parameters of the deleted equation will be obtained via additivity constraint, which is as follows.

$$\sum_{i=1}^{4} \alpha_{i0} = 1, \quad \sum_{i=1}^{4} \gamma_{ij} = 0, \quad \sum_{i=1}^{4} \beta_i = 0 \quad (19)$$

If the homogeneity $\left(\sum_{j=1}^{4} \gamma_{ij} = 0\right)$ and symmetry $(\gamma_{ij} = \gamma_{ji})$ constraints are applied on the model according to the economic theories, demand system is presented as follows after the removal of the last equation.

$$\begin{cases} WE = \alpha_{10} + \gamma_{11} Ln\left(\frac{PEr}{PT}\right) + \gamma_{12} Ln\left(\frac{PGr}{PT}\right) + \gamma_{13} Ln\left(\frac{POr}{PT}\right) + \beta_1 Ln\left(\frac{X_i}{p^*}\right) + U_1 \\ WG = \alpha_{20} + \gamma_{21} Ln\left(\frac{PEr}{PT}\right) + \gamma_{22} Ln\left(\frac{PGr}{PT}\right) + \gamma_{23} Ln\left(\frac{POr}{PT}\right) + \beta_2 Ln\left(\frac{X_i}{P^*}\right) + U_2 \\ WO = \alpha_{30} + \gamma_{13} Ln\left(\frac{PEr}{PT}\right) + \gamma_{23} Ln\left(\frac{PGr}{PT}\right) + \gamma_{33} Ln\left(\frac{POr}{PT}\right) + \beta_3 Ln\left(\frac{X_i}{P^*}\right) + U_3 \end{cases} \quad (20)$$

4. RESEARCH FINDINGS

Energy has always been one of the important and decisive arguments in all industries of the world and energy consumption is considered as one of the major determinants of the products' cost price. In the Khuzestan province energy consumer industries, lack of appropriate economic policies in order to save, increase the efficiency and optimizing the production, has led this part not to be able to use all of its potentials. On the other hand, energy is one of the determinants of investment location; because existence of energy and possibility of its availability is the main reason for investing in different industries and the reason for some industries such as petrochemical, steel, and ... companies in Khuzestan province is existence of much energy. Energy consumption, especially fossil energy, causes environmental pollution. In industrialized countries, even in the case of availability and economic status of fossil energy, its usage is restricted due to pollution that it creates. But, in Iran, fossil, solar and wind energy sources, are more important than employment and added value. In the industrial sector, the demand of the firms for energy is derived from the demand for the firm's product as an input so that this demand depends on the level of the firm's product. In fact, a manufacturing firm uses energy as an input to produce goods and services. In this section, we will estimate the demand function for the industry energy in both unbound and bound approaches.

4-1. the co-integration and reliability tests

Before estimation, it is necessary to do the reliability and co-integration tests on all variables. The results of the reliability test are summarized in the below table.

Table 1. Results of Dickey - Fuller Test in the industrial sector

Variable	Dickey - Fuller Test	Probability
LPE2	-2.60	0.099
D(LPE2)	-4.79	0.000
LPG2	-1.37	0.59
D(LPG2)	-3.51	0.046
LPO2	-1.06	0.73
D(LPO2)	-7.43	0.000
LPT	-1.49	0.53
D(LPT)	-6.44	0.000
WE2	-0.76	0.82
D(WE2)	-8.11	0.000
WG2	-1.23	0.66
D(WG2)	-9.15	0.000
WO2	-2.48	0.13
D(WO2)	-9.11	0.000

The results indicate that all the variables of this part will be reliable after a difference. Also, the two-stage Engel - Granger test is summarized in Table 2. The detailed results of these tests can be found in the appendices.

Table 2. Results of Engel - Granger test in the industrial sector

Variable	Engel - Granger test	Probability
RESIDWE1	-7.64	0.000
RESIDWG1	-8.24	0.000
RESIDWO1	-4.26	0.000

The results of this test show that the remainders are reliable and so there is a long-term relationship between the variables. So, given that the long-term relationship is confirmed, the long-term demand system for energy carriers can be estimated based on the level of the variables without fear of regression. The results of estimation in this section shows that own-price coefficients of energy carriers are positive and they are likely to be highly significant and the highest own-price coefficient is related to electricity, which shows the industry's dependence on this energy carrier. The obtained own-price elasticities are all less than one. Income elasticity also indicates that the energy carriers in this sector are considered as an essential item.

4-2. unbound state

Demand unbound equations system for energy carriers in this sector is as follows.

$$\begin{cases} WE_2 = 0.059 + 0.004LnPE_2 - 3.5e^{-4}LnPG_2 - 0.001LnPO_2 - 0.0001LnPT - 0.002Ln\left(\frac{X_2}{P^*}\right) \\ WG_2 = 0.0047 + 7.7e^{-6}LnPE_2 + 1.3e^{-4}LnPG_2 + 5.1e^{-5}LnPO_2 + 1.2e^{-4}LnPT - 2.1e^{-4}Ln\left(\frac{X_2}{P^*}\right) \\ WO_2 = 0.011 - 2.1e^{-4}LnPE_2 + 3.5e^{-5}LnPG_2 + 3.0e^{-4}LnPO_2 + 2.6e^{-4}LnPT - 4.8e^{-4}Ln\left(\frac{X_2}{P^*}\right) \\ WT_2 = 0.93 - 1.7e^{-4}LnPE_2 + 1.9e^{-4}LnPG_2 + 6.5e^{-4}LnPO_2 - 2.7e^{-4}LnPT - 0.003Ln\left(\frac{X_1}{P^*}\right) \end{cases}$$

The results of estimating this system of equations using the ISUR and $I3SLS$ approaches are given in the appendix. The obtained results in both methods are almost identical. In this section, as in the previous section ISUR and $I3SLS$ methods are compared via statistic in Table 3 that at the end, ISUR method is more suitable.

Table 3. Comparison between ISUR and $I3SLS$ approaches in the industrial sector

ISUR						I3SLS					
Description	R^2	ML	F	AIC	SBC	Description	R^2	ML	F	AIC	SBC
Electricity	0.97	194.67	388.99	-5.31	-5.33	Electricity	0.95	186.85	230.51	-5.09	-5.107
Gas	0.86	255.91	82.58	-7.039	-7.05	Gas	0.84	252.95	66.2	-6.96	-6.97
Oil	0.89	226.47	105.86	-6.21	-6.22	Oil	0.89	226.44	105.44	-6.21	-6.22

Table 4. Results of the estimation of unbound LA/AIDS system in the industrial sector via ISUR approach (Numbers in parentheses indicate the statistics)

Description	a^{i0}	c^{i1}	c^{i2}	c^{i3}	c^{i4}	c^{i5}	R^2	DW
Electricity	0.059 (5.39)	0.0047 (2.78)	-0.00035 (-1.2)	-0.001 (-5.07)	-0.00011 (-0.23)	-0.0021 (-43.4)	0.96	1.75
Gas	0.0047 (2.78)	68.7 e^{-5} (0.12)	0.00013 (2.23)	5.12 e^{-5} (1.87)	0.00012 (1.68)	-0.00021 (-2.88)	0.86	2.11
Oil	0.011 (5.08)	-0.00021 (-3.32)	3.53 e^{-5} (0.5)	0.0003 (5.21)	0.00026 (2.63)	-0.00048 (-5.23)	0.89	2.011
Other	0.93	-1.68 e^{-4}	1.85 e^{-4}	6.488 e^{-4}	-2.7 e^{-4}	-2.79e^{-3}	-	-

The results in Table 4 show that out of 18 estimated parameters, 6 parameters are not significant at the level of 5%. The amounts of R^2 and DW for the estimated equations for electricity are equal to 0.96 and 1.75 and for gas they are equal to 0.86 and 2.11 and for petroleum products, they are equal to 0.89 and 2.011.

Self-coefficients i.e. c^{ii} are positive in the table and this suggests that through increasing the real price of each energy carrier in proportion to the total energy expenditure, the costs of that energy carrier in the industrial sector will be increased. It should be noted that

C Note that c^{ii} of all the carriers are significant with very high levels of possibility. The reason for this is that the procedure of changes in the amount of consumption and nominal price of each carrier are perfectly aligned with each other and their fluctuations are roughly coordinated.

The coefficients of unbound cross and own price elasticities are presented in table 5 via ISUR approach. For example, own price elasticity of electricity is as follows.

$$\mu_{ii} = \frac{\gamma_{ii}}{w_i} - 1 - \beta_i \Rightarrow \mu_{11} = \frac{0.0037}{0.053} - 1 + 0.0021 = -0.99$$

Also, for example, the cross-elasticity of gas for electricity is calculated as follows.

$$\mu_{ij} = \frac{\gamma_{ij}}{w_i} - \beta_i\left(\frac{w_j}{w_i}\right) \Rightarrow \mu_{12} = \frac{-0.00035}{0.053} + 0.0021\left(\frac{0.0038}{0.053}\right) = -0.00645$$

Table 5. Unbound price elasticity of energy carriers in the industrial sector

Description	Electricity	Gas	Oil	Other
Electricity	-0.99	-6.45 e^{-3}	-0.02	0.037
Gas	4.95 e^{-3}	-0.96	0.031	0.084
Oil	-0.047	9.51 e^{-3}	-0.92	0.19
Other	-0.0036	-0.00017	0.00072	-1

Own and cross elasticity of energy carriers in the industrial sector shows that the own price elasticity of energy carriers are negative, which are consistent with demand theory. Own price elasticity for electricity, natural gas and petroleum products are 0.99, 0.96 and 0.92, respectively that shows the inelasticity of energy carriers.

About cross-elasticity in this sector it should be said that substitution and complementary relationships in this sector is very weak and even weaker than domestic and commercial sectors. Maybe it could be due to the use of different technologies in applying the energy carriers in this sector. However, gas and petroleum products are considered as supplements (weak) of electricity. Electricity and petroleum products are considered as alternatives (weak) of gas. Gas is considered as an alternative (weak) and electricity is considered as a supplement (weak) for petroleum products. About other products in this sector, it should be said that the own price elasticity for these goods is one and it is considered as an alternative (weak) in this sector. Petroleum products for other goods are considered as an alternative (weak) and electricity and gas for other goods are considered complementary (weak). The results of unbound income elasticity are mentioned in Table 6. For example, the income elasticity of electricity in this part is achieved as follows.

$$\eta_i = \frac{\beta_i}{w_i} + 1 \Rightarrow \eta_1 = -\frac{0.0021}{0.053} + 1 = 0.96$$

Table 6. Unbound income elasticity of energy carriers in the industrial sector

Description	Electricity	Gas	Oil	Other
Industry	0.96	0.94	0.87	1

The obtained income elasticity in table 6 shows that income elasticity of energy carriers in this sector such as domestic and commercial sectors are all less than one and these energy carriers are considered as necessary goods. The obtained income elasticity for electricity, gas and petroleum products are 0.96, 94, and 0.87, respectively.

4-3. bound state

Only one homogeneous constraint related to the third equation and two symmetry constraints have been accepted via Wald test. The results of these tests are given in the appendix. Accepted homogeneity and symmetry constraints are as follows:

$$c_{12} = c_{21}$$
$$c_{23} = c_{32}$$
$$c_{31} + c_{32} + c_{33} + c_{34} = 0$$

System of equations in the bound state of industrial sector is as follows.

$$\begin{cases} WE_2 = 0.05 + 0.003 LnPE_2 - 1.8e^{-5} LnPG_2 - 0.001 LnPO_2 - 4.3e^{-4} LnPT - 0.002 Ln\left(\frac{X_2}{P^*}\right) \\ WG_2 = 0.005 - 1.8e^{-5} LnPE_2 + 1.0e^{-4} LnPG_2 + 6.5e^{-5} LnPO_2 + 1.3e^{-4} LnPT - 2.3e^{-4} Ln\left(\frac{X_2}{P^*}\right) \\ WO_2 = 0.003 - 3.0e^{-4} LnPE_2 + 6.5e^{-5} LnPG_2 + 2.7e^{-4} LnPO_2 - 5.5e^{-5} LnPT - 1.4e^{-4} Ln\left(\frac{X_2}{P^*}\right) \\ WT_2 = 0.94 - 0.003 LnPE_2 - 0.002 LnPG_2 + 7.7e^{-4} LnPO_2 + 3.4e^{-4} LnPT - 0.002 Ln\left(\frac{X_2}{P^*}\right) \end{cases} \quad (20)$$

The estimated coefficients of the equations system bound to the theoretical limitations (additively, homogeneity and symmetry) is presented in Table 7using ISUR method.

Table 7. Results of the estimation of bound LA/AIDS system in the industrial sector via ISUR method

Description	$\mathbf{a^{i0}}$	$\mathbf{c^{i1}}$	$\mathbf{c^{i2}}$	$\mathbf{c^{i3}}$	$\mathbf{c^{i4}}$	$\mathbf{c^{i5}}$	R^2	DW
Electricity	0.052 (4.8)	0.003 (13.2)	-1.76 e^{-5} (0.26)	-0.0011 (-5.87)	-0.00043 (-0.93)	-0.0018 (-3.78)	0.97	1.74
Gas	0.0053 (3)	-1.76 e^{-5} (0.26)	0.0001 (2.24)	6.48 e^{-5} (2.52)	0.00013 (1.96)	-0.00023 (-3.14)	0.86	2.14
Oil	0.003 (3.56)	-0.0003 (-5.43)	6.48 e^{-5} (2.52)	0.00027 (4.8)	5.48 e^{-5}	-0.00014 (-4.87)	0.87	2.00
Other	0.94	-0.0027	-0.00187	0.000765	0.000345	-0.00217	-	-

The above table shows that out of 17 estimated parameters, 4 parameters are not significant at the level of 5%. The amounts of R^2 and DW for electricity are equal to 0.97 and 1.74, for natural gas they are equal to 0.86 and 2.14 and for petroleum products, they are equal to 0.87 and 2.00. Own coefficients i.e. c are positive in the table. The results of bound cross and own price elasticity are presented in table 8. Price elasticity of energy carrier in this state are negative and less than one. Cross elasticity (except electricity for gas) shows similar results with previous state.

Table 8. Bounded price elasticity of energy carriers in the industrial sector

Description	Electricity	Gas	Oil	Other
Electricity	-0.94	-0.0002	-0.021	0.026
Gas	-0.0014	-0.96	0.017	0.097
Oil	-0.07	0.017	-0.92	0.021
Other	-0.0028	-0.00019	0.00076	-1

Table 9. Bounded income elasticity of energy carriers in the industrial sector

Description	Electricity	Gas	Oil	Other
Industry	0.97	0.94	0.96	1

Income elasticity are almost identical in both cases and these elasticity for energy carriers show the necessity of this commodity.

In the case of other commodities, it should be said that they have a unit own price elasticity and electricity and gas are supplement commodities (weak) and petroleum products are considered their substitute (weak). Furthermore, other commodities for energy carriers are considered substitute commodities.

4-4. investigating the results in the industrial sector

Investigating the results of estimating the demand equations for energy carriers using ISUR in the industrial sector in both states of unbound and bound to the theoretical limitations (aditivity, homogeneity and symmetry) implies that in the unbound state, out of 18 estimated parameters, 6 parameters are not significant at the level of 5%, while in the bound state, out of 17 estimated parameters, 4 parameters are not significant. Price elasticity in both unbound and bound states are presented in table 10.

Table 10. Comparing price elasticity of energy carriers in the industrial sector in the unbound and bound states

Unbound					Bound				
Description	Electricity	Gas	Oil	Other	Description	Electricity	Gas	Oil	Other
Electricity	-0.99	-6.45 e^{-3}	-0.02	0.037	Electricity	-0.94	-0.0002	-0.021	0.026
Gas	4.95 e^{-3}	-0.96	0.031	0.084	Gas	-0.0014	-0.96	0.017	0.097
Oil	-0.047	9.51 e^{-3}	-0.92	0.19	Oil	-0.07	0.017	-0.92	0.021
Other	-0.0036	-0.00017	0.00072	-1	Other	-0.0028	-0.00019	0.00076	-1

The price elasticity in both unbound and bound states have little difference. Elasticity of three types of energy carriers have the expected sign and they are less than one; it means that these energy carriers in this sector are inelastic. About own price of other goods, we can say that elasticity in both states are equal to the unit. About cross elasticity we can say that in both states, the elasticity have little difference with each other and the only difference is related to the relation of electricity and gas that in the unbound state, electricity is a substitute of gas and in the bound state, electricity is a supplement of gas. In other cases, the elasticity' signs are identical. But it should be noted that supplement and substitution relation in the unbound state is weaker than bound state. The results of the obtained income elasticity of this part are presented in table 11.

Table 11. Comparing the income elasticity of energy carriers in the industrial sector in the unbound and bound states

Unbound					Bound				
Description	Electricity	Gas	Oil	Other	Description	Electricity	Gas	Oil	Other
Industry	0.96	0.94	0.87	1	Industry	0.97	0.94	0.96	1

Income elasticity in three energy carriers in the bound and unbound modes do not differ much and they are all less than one; it means that energy in this sector, is a necessary commodity. Income elasticity of other goods in both bound and unbound states is equal to the unit.

5. DISCUSSION AND CONCLUSION

In this section, just the homogeneity constraint for petroleum products has been accepted. Symmetry constraints for two groups of electricity and natural gas are accepted via Wald test. Demand own price elasticity in both bound and unbound states have the expected sign and they are less than one. It means that energy in this sector is an inelastic commodity. Major reasons of energy inelasticity in this sector are the lack of flexibility and adhesion in the technology which makes the possibility to save the energy weak; because usually technology changes and savings the costs do not have economic justification. However, the real cost of energy in this sector is low. Own price elasticity for other commodities are negative and equal to the unit. Cross elasticity in this part show the low amounts. In both states, petroleum products are complemented by electricity and replaced by natural gas. But in both cases the cross elasticity of electricity and natural gas in this sector, do not show the same results. Income elasticity in both bound and unbound modes are all less than the one and they show the necessity of energy carriers in this sector. In both cases the highest income elasticity is related to electricity which shows the industry's dependence on this energy carrier. Income elasticity for other goods in both cases has been obtained equal to the unit.

According to the importance of energy consumption in the industrial sector, it is necessary for the economic, environmental, technological and social outcomes due to consuming any type of energy to be evaluated for the coming years and the decisions necessary to determine future policies in the energy sector should be made. Among the provinces of the country, in Khuzestan province because of accumulation of oil, gas, petrochemical and steel industries and weather conditions on the one hand and having enormous and rich resources of production and supply of electricity on the other hand, doing such research is essential.

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