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Investigating the Factors Affecting Energy Consumption in the Iranian Agricultural Sector Using Parametric and Nonparametric Methods

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Abstract

In order to study energy consumption in Iran's agricultural sector, a Genetic algorithm concept was used to calculate significant factors affecting energy consumption between 1974 and 2008. Then, durability or "stability" of variables was assessed through econometric method (Augmented Dickey-Fuller test). In addition, long-term and short-term relationships of energy consumption were estimated using Vector Error Correction Model (VECM). Results of this study reveal that intensity of energy consumption variables in agricultural sector and Gross Domestic Product (GDP) are of great importance and have a considerable impact on energy consumption in agricultural sector of Iran. Therefore, these factors can be beneficial for policies of energy consumption conservation in agriculture sector.

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1. Introduction

Iran, as a developing country with enormous energy resources, extensive oil reservoirs and large mineral deposits, is an example of growth based on over-exploitation of natural resources (Barati Malayeri and Hoori Jaffari, 2008). Therefore, prudent and balanced planning for production and consumption of energy is of utmost importance. Relative abundance of energy resources in Iran is the main reason for higher consumption of energy per capita (amount of energy consumed to produce certain amount of goods or services) compared to other countries with similar economic structures and less energy resources (Energy Balance sheets, 2002). Scientific and economic studies in the field of energy needs have been taken into consideration by economists regarding two aspects. First, the irretrievable depletion of fossilized resources which supply the greatest portion of world's demand for energy and second, environmental effects resulted from consumption of these resources. Generating new energies is too expensive and time consuming. Therefore, industrial countries prefer to use fossil resources. Hence, these countries try to use scarce and deployable resources of third world countries. Further efforts to obtain new energies depend on clear scientific analysis to provide future needs. Thus, studying energy consumption in all economic sectors, especially in agriculture, is of great importance. Studying energy consumption based on new and efficient scientific models would help us find ways to deal with this problem, to make recommendations and to support investments (Haydari, 2004). Cheap energy resources and existence of some factors like absence of modern technology in industrial factories, construction, agricultural production and transportation have increased energy consumption in Iran in comparison with other developed or developing countries. This phenomenon is not only detrimental to environment and sustained economic development but it also imposes heavy costs on national economy. Concerning extremely high subsidization expenses, making use of energy resources logically and designing some programs for obtaining optimal energy consumption seems very urgent. The greatest portion of energy sources in Iran (i.e. 98.5 percent) comes from fossil fuel; unfortunately, the largest subsidy was allocated to these resources in 1974-2008 periods. The aim of this paper is to study energy consumption in Iran agricultural sector using parametric and nonparametric methods.

Determining and analyzing the effective factors on energy demand

and consumption are of great importance in economics. In order to investigate these factors, econometric methods such as causal are used. Some studies done in this area are mentioned below.

Esmailnia (1999) estimated the function of petrol and gas oil demand from 1967 to 1998. The results showed that petrol is low- elasticity to keep its price low, it is fixed. There is not also an alternative for it. In his study, Heidari (2004) investigated the role of energy intensity and economic sector's share in energy consumption. He concluded that these two factors had a positive effect on energy consumption. Using annual data from 1970 to 1999, Oh and Lee (2004) examined the relationship between energy consumption and economic growth in Korea. They also used a four-variable Vector Error Correlation Model (i.e. Gross Domestic Product, energy consumption, employment and capital) to study the relationship between energy consumption and economic growth; they showed that increased energy consumption entails substitution of labor force and capital. The result of long-term and short-term causality test also indicates that there is a two-sided causality relationship between energy consumption and Gross Domestic Product in the long-term. Hondroyiannis et al. (2002) studied the relationship between energy consumption and economic growth in China. Similarly, they studied the actual relationship between energy consumption and economic growth using a Vector Error Correction Model. Their model consists of energy consumption variables, real GDP and energy price. It shows that there is a long-term relationship between variables. Mahadevan and Asafu-Adjaye (2007) examined the relationship between energy consumption and real GDP in developed and developing countries. According to a combined error correction model and using data from 1971 to 2002, they showed that there was a two-sided long-term and short-term causality relationship between economic growth and energy consumption in developed exporting countries. In developed exporting countries, however, energy consumption positively affects economic growth only for a short time. In importing countries, whether developed or developing, there is a two-sided causality relationship between energy consumption and economic growth in short term as well as long term. Amongst importing countries, there is a one-sided causality relationship between energy consumption and economic growth only in developed countries.

Based on Juselius and Johansen Co-Test within the framework of

Vector Auto-Regressive Model, Zibaii and Tarazkar (2004) studied long-term and short-term relationships between value added and energy consumption in agricultural sector of Iran from 1967 to 2000. They showed that there is a long-term causal relationship between value added and energy consumption whether in the form of electricity or petroleum products. In short term, value-added induces high electrical energy consumption, while there is no short-term relationship between value added and consumption of petroleum products. Applying Vector Error Correction Model, Sohaily (2002) studied dynamic relationships between GDP, demand for energy prices and energy demand in Iranian economy. To obtain figures reflecting demand for oil by-products, electricity and natural gas, he estimated three distinct models; GDP, quantity of the mentioned energy and price of that energy carrier were considered as endogenous variables. Nowadays, non-parametric models are greatly considered in economic analysis. Sadeghi et al. (2009) used genetic algorithm to estimate petrol demand function in transportation system. Petrol demand was considered as a function of GDP, petrol price, population, the number of cars using petrol and consumption efficiency. The results showed that the second grade model was more useful in estimating petrol demand in comparison with other models. Haldenbilen and Ceylan (2005) estimated the function of energy demand in Turkey's transportation system from 1970 to 2000 by GA and linear, quadratic and exponential models. In this study, the data obtained from 1970 to 1995 were used to estimate the model, while the data obtained from 1996 to 2000 were used to validate the models. Finally, the energy consumption in transportation system by 2020 was predicted. Some other studies done to investigate the GA usage in estimating the functions of energy carrier demand are the ones done by Ozturk et al. (2004) to estimate the production and consumption of oil products in Turkey, and Canyurt and Ozturk (2008) estimate the fossil fuel demand in Turkey.

2. Methodology

2.1 Error Correction Model (ECM)

Whenever involved variables are co-integrated in model, in order to determine the short-term behavior of these variables, we make use of ECM Method which was first introduced by Engle and Granger (1987). Meanwhile, in this model, two variables may be occasionally co-integrated (i.e. there is a long-term equilibrating relationship between the two, whereas in short-term there appears almost no equilibrium). ECM attempts to correct this short-term absence of equilibriums (Noferesti, 1999). Therefore, if total energy (equivalent to one million barrels of crude oil) consumed in all manufacturing sectors of national economy is represented by E, the consumed energy is shown by I, and the sector (million barrels of crude oil) is represented by E_i (Haydari, 2004), then

$$E = \sum_{i=1}^{n} E_i \tag{1}$$

We can rewrite this equation as

$$E = \sum_{i} (E_i / Q_i).(Q_i / GDP).GDP \tag{2}$$

Where Q_i is value added in i_{th} sector (million Rials), GDP is Gross Domestic Product (million Rials), I_i is energy intensity in i_{th} sector (million barrels of crude oil/million Rials) and S_i is share of i_{th} sector in GDP. In other words

$$I_i = E_i / Q_i \qquad S_i = Q_i / GDP \tag{3}$$

To represent this sector's share in GDP using formula (2), we have:

$$E = \sum_{i} I_i.S_i.GDP \tag{4}$$

Price of energy in agricultural sector (P) along with GDP, S and I are the factors that affect energy consumption. Total energy consumed in agricultural sector of Iran consists of various oil and electricity by-products. In order to calculate the price of energy consumed in this sector, we simply multiply the quantity of oil by-products and electric power consumed in the agricultural sector by their respective prices.

2.2 Genetic algorithms approach (GA)

The idea of Evolutionary Computing was introduced in a book named, *Evolution Strategies* by Rechenberg in 1960s. Then, this idea was developed by other researchers. GA, which is based on evolutional calculation, was first introduced by John Holland in 1975 (Holland, 1992). GA as an efficient method is used to solve complicated problems in commercial, scientific and engineering fields. Genetic Algorithm is a searching technique in computer science. It is used to find approximate solutions for optimizing and searching Genetic algorithm is a special type of algorithms which uses some return biological techniques such as inheritance and mutation. In fact, GA is one of Darwin's natural selection principles used to find the optimal formula for predicting or matching patterns. It is an appropriate forecasting technique based on regression. GA tries to find the best maximum or minimum option of a function. It produces a set of random initial population of chromosomes for the problem, and then it solves the method using the hereditary operators (mutation and Hmbry). It can make better solutions out of the current set of chromosomes. In a hereditary algorithm, an appreciate number is allocated to each solution. This value is a numerical estimate of its ability to solve the problem. So, selecting a solution with higher sufficiency will be the main objective. In this case, new generation will have tendency to optimal reply. Choosing the correct sufficiency function is important in converging and performing the algorithm. Sufficiency function has allocated a number to each chromosome. It is proportional to their sufficiency abilities. This function is directly achieved from the objective function. Fitness of function is estimated for all chromosomes. It will be their criteria of assessment and optimization. Hereditary algorithm is appropriate for finding maximum value of objective function. In this study, the objective was to minimize; therefore, it used some schemes to maximize this problem. Figure 1 shows Genetic algorithms process diagram (Ismaili and Tarazkar, 2005).

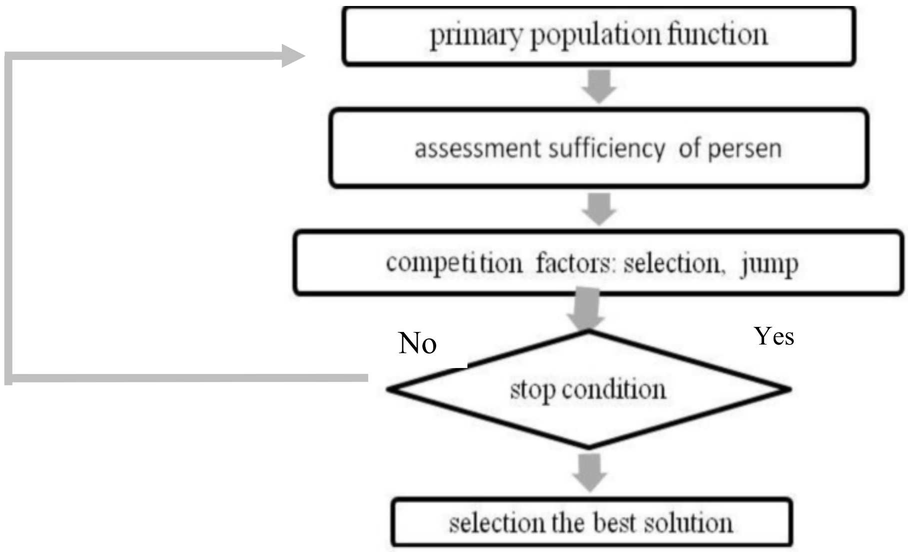

Figure 1: View of genetic algorithms

Estimating consumption function by genetic algorithms (Ismaili and Tarazkar, 2005):

$$E = w_0 + w_i \sum_{j=1}^{n} x_j \qquad -10 \le w_i \le 10, \quad j = 1,2,\ldots,4 \qquad (5)$$

W_i is weighted factor determinate by GA while optimizing sufficiency and objective function and x_i are independent variables Sufficiency function is explained as follows:

$$obj = \frac{1}{MSE} = \left(\frac{1}{m}\sum_i^m \left(E_{obs}(i)\right)^2\right)^{-1} = \left(\frac{1}{m}\sum_i^m e^2(i)\right)^{-1}, \qquad (6)$$

$$i = 1,2,\ldots,m$$

Where MSE the mean is squared errors; E_{obs} is observed consumption energy function and E_{ost} is estimated consumption energy function and m is numbers of observations.

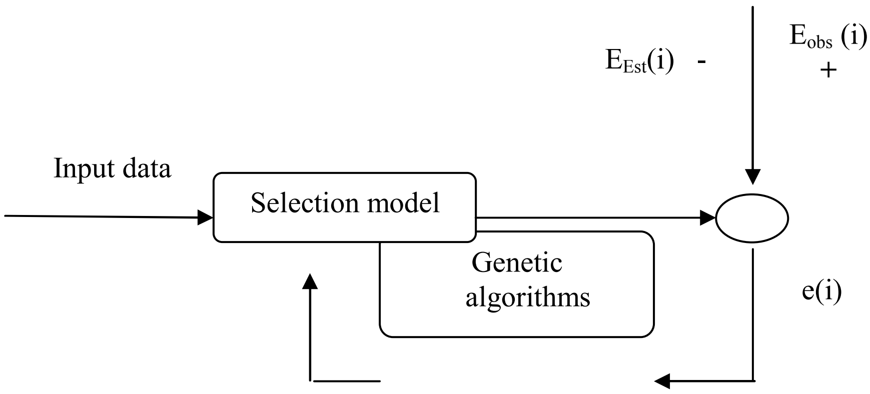

Figure 2: Estimation of demand functions by genetic algorithms

In the next section, energy consumption will be examined in Iran's agricultural sector using genetic algorithm and VECM techniques**.**

3. Discussion and Results

In order to investigate the effective factors on energy consumption in agriculture sector, the equation (5) is estimated by GA. Since the GA is able to show the importance of each independent variable in describing dependent variables as a number called "importance coefficient", these coefficients were first determined, that shown in table(1).

It is worth mentioning that Importance Coefficients more than 0.2 implies that the particular variable has indeed affected the dependant variable. According to importance coefficients, it is expected that energy intensity, agricultural sector's share and GDP have respectively the most effects on this sector. The energy price in the studied period, as a result of government support, is not effective on energy consumption.

Table 1: Results of genetic algorithm about variables affecting energy consumption in agricultural sector

Variable	Importance Coefficient
Energy consumption intensity	0.532
Agricultural sector share	0.291
Gross Domestic Product	0.177
Energy price	0.000
R^2=0.9772	

The long-term relation will be estimated by VECM method and GA.

Since studied variables are highly explanatory, Vector Error Correction Model can be easily used to forecast and to study the factors affecting energy consumption in agricultural sector.

Application of usual econometric methods to estimate pattern coefficients (by means of time-serial data) is based on this assumption that pattern variables are stable. Before estimating the pattern, the stability of variables was assessed; to do this, Augmented Unit-Root Dicky-Fuller Test was used and the results are presented in Table (2).

Table 2: Results up Unit Root Test

Variable	Model	Stationary degree	Logs	ADF
dE	Intercept	I(1)	0	-6.0447
dI	Intercept	I(1)	0	-5.3881
dS	Intercept	I(1)	0	-5.2185
dGDP	Intercept	I(1)	0	-3.1381
dP	Intercept	I(1)	0	-3.1350

Note that critical Dicky-Fuller statistics at 1% level is equal to 3.6616; at 5% is equal to -2.9604; and at 10% is -2.6191.

According to calculated Unit root test, all of the above variables are first degree static (integration I(1)) and therefore for Error Correction Model we have to determine the number of optimal lags.

To estimate the long term relationship between the variables, Johansson's co-integration method was used. In this method, determining the length of optimal lag is necessary; it is one according to AIC, SC and HQ.

Table 3: Results of Optimal lag test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-584.44	NA	2.26e+10	38.02863	38.25991	38.10402
1	-410.60	280.3772*	1562472.*	28.42644*	29.81417*	28.87880*
2	-387.86	29.34653	2071803	28.57202	31.11619	29.40135

Subject to all conditions and criteria, optimal lag of the model is one. Having determined stability degree and optimal lag, VEC Model can be used for forecasting.

3.1 Estimated Results of VEC Model

The VEC Model is:

$$E(-1) = -0.77\left[\; -22.21183.I(-1) - 12.28702.S(-1) - 0.0001.GDP(-1) + 0.0003.P(-1) + 33.929 \;\right]$$

$$(-13.6220) \qquad (-17.1381) \qquad (-13.1534) \qquad (1.251) \quad (7)$$

$$-0.752.D(E(-1)) + 10.741.D(I(-1)) + 41.949.D(S(-1)) + 0.0001.D(GDP(-1)) + 0.0004D(P(-1)) + 0.226$$

$$(-2.3417) \qquad (1.139) \qquad (0.739) \qquad (2.764) \qquad (1.370) \qquad (0.584)$$

Energy intensity, which reflects the amount of energy consumed per unit of GDP and is expressed in Rials per barrel of crude oil according to local prices, has a significant influence on energy consumption in agricultural sector.

GDP has increased from 219191 billion Rials in 1974 to 499071 billion Rials in 2006. (Central Bank of Iran 2008). Future index of energy intensity is a dependent function of productivity and optimization of policies regarding energy consumption in relevant governmental departments. Some of these policies available from the first socio-economic development plan (and are recommended to be used in future) are modification of energy price, continuous increase in energy prices, energy auditing, energy labeling, motivational policies and development of markets for efficient performance. If these policies continue to work in future, one could expect that intensity of energy in various economic sectors would correspondingly decrease. According to the time of energy intensity, consumption of oil by-products will decrease, but electricity consumption will increase.

Agriculture share in national economy has a significant effect on energy consumption. In other words, the variables indicate the status of economic structure and show that the sector share affects the energy consumption.

GDP has also a substantial influence on energy consumption in agricultural sector where energy is an essential input. Examining energy figures in agricultural sector shows that consumption of all kinds of energy including oil by-products and electric power (along with increases in production and value added) has increased during past years.

Energy, as an indispensible factor of production, directly affects production; thus, any increase in agricultural production indicates an increase in energy consumption. However, price of energy in agriculture has such a minimal negative effect on energy consumption that it is statistically negligible. It shows that energy consumption in agricultural sector is not related to variable “price”. Energy prices in Iran's agricultural sector, however, are heavily controlled and subsidized by the government. In other words, energy prices, particularly prices of oil by-products, are extremely low in agricultural sector and have no influence on consumption of energy in this sector. Adjustment coefficient of -0.77 shows that changes in each period are adjusted according to this coefficient. Energy consumption function has been estimated in Iran agriculture sector using genetic algorithm which is shown by this equation (8).

$$E(-1) = 26.101I(-1) + 13.7001S(-1) + 0.00012.GDP(-1) -$$
$$0.00024.P(-1) - 32.032$$
$$(-12.6315) \qquad (-15.2873) \qquad (-14.1621) \qquad (1.2823) \qquad (8)$$

Taking into account the GA optimization that is shown in equation 8, GDP, consumption intensity and agricultural sector's share had a positive and significant effect on energy consumption, while the price had a negative and not significant effect. These results confirm the VECM model's results (equation 7). The results of 7^{th} and 8^{th} equations conform to GA importance coefficients. The real and estimated amounts by GA are shown in diagram (1).

The real and estimated amounts are very close to each other, which reveal the high accuracy of GA.

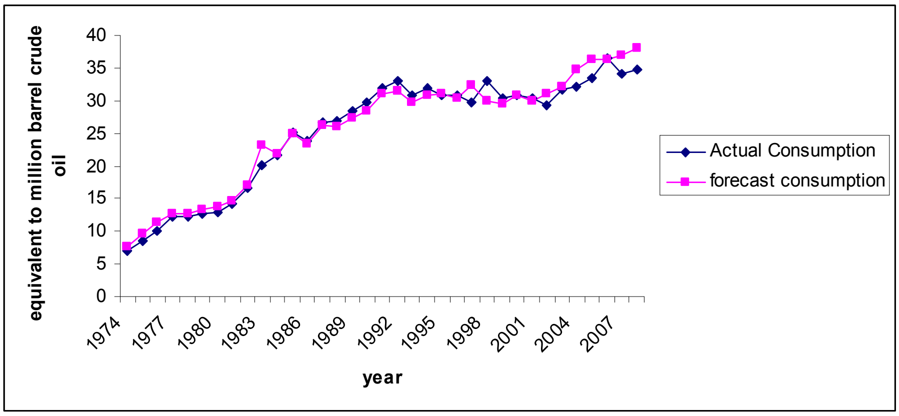

Diagram 1. Actual and predicted figures on energy consumption in agricultural sector

4. Conclusions

Trying to use energy sources better has been considered recently; agricultural sector has done so. In addition, regarding the environmental consideration, decreasing inputs out of field, especially energy, is considerable. Gas oil is the main source of energy in agricultural sector; by 2006, 70% of energy consumed in this sector was gas oil. There is always a great tendency toward using this important input in agricultural sector. GDP increase is a necessary condition for economic development of each country. Since there is a positive relationship between GDP and energy consumption, GDP decrease cannot be used to decrease energy consumption. In economic development process, the agricultural sector's share will decrease and as a result, it is expected that its share in energy consumption will decrease. Structural changes in economics may also cause the energy intensity decrease. In order words, advanced technology and new sources of energy can decrease the energy intensity; therefore energy consumption in agricultural sector will decrease. The results of this study are in line with the study done by IMF (2010).

Governments pay subsidies on energy in order to achieve better economic growth, to increase employment, to control prices, and to establish social justice. Food production and food security are of great importance; consequently, energy prices in agricultural sector are under strict support of the government. Therefore, energy prices have no effect on level of energy consumption in this sector. Since the energy intensity reflects the final level of energy consumption per unit (production or value added), its impact actually measures variations in consumption as a result of any change in intensity of energy itself. Negative contribution of this impact over two years indicates a decrease in consumption due to decrease in energy intensity; it also shows energy saving. Energy intensity is highly affected by resources utilization methods and by energy-consuming equipment. Therefore, the effect of energy intensity is considered a key factor in every study carried out on economy of energy consumption.

Increased productivity in agricultural sector has brought about a marked decrease in energy consumption. Therefore, application of up-to-date technologies, modernization and making use of hybrid seeds will result in noticeable decrease in energy intensity in this sector.

A great amount of energy (gasoline) is used to extract water in agricultural sector so reducing fuel and energy subsidy is a good way to save energy in this sector. Authorities should consider the fact that agricultural sector is in charge of providing food for the country. Therefore, they should try to reduce the agricultural subsidy and should support this sector.

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