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A Survey of the Causality Relation between Energy Consumption and Economic Growth in Iran

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Abstract

The study of the reasons of economic growth is of great importance and it is always considered by many economists. Improving life quality of people and increasing public welfare are the goals of various governments in the world and economic growth is one of the important factors in achieving these goals. Thus, searching about the factors effective on economic growth is of great importance. The present study evaluated the relationship between energy consumption and economic growth in Iran and time series data were used during 2009-1971. To estimate model, vector error correction model (VECM) is used. The results showed that there is a two-way causal short-term and long-term relationship between energy consumption and economic growth.

Key Words: Energy consumption, economic growth, Iran, Granger causality relation, VECM

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Introduction

Human being considered the importance of energy for continuing life from the creation and they dedicated considerable part of their ability to provide required energy and it can be said energy sources have important role in communities' progress. As energy is driving force of each manufacturing activity, it has special position in economic growth. Now, energy is mostly applied in required goods production process and providing suitable conditions of life. Increasing dependency of human life on

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energy resources caused that these sources are considered as effective factors in economic development. Iran has rich energy sources, great oil reservoirs and natural gas, great underground resources and potential of energy. Determining the relationship between energy consumption and economic growth can be useful in determining the policies of energy sector. Restricting energy consumption namely oil products as petroleum is on priority of economic policies of government and the shortage of energy sources is problematic for various economic sectors and determining the relationship between energy consumption and economic growth can be a good guidance for policy makers of energy and economy sectors of the country.

The present study investigated the causal relationship between energy consumption and economic growth. This question is answered: Is there any causal relationship between energy consumption and economic growth? If it is yes, is it one-way or two-way?

At first, we review the theoretical and empirical basics of the relationship between energy consumption and economic growth. By the annual data during 1971-2009, the long-term causality relationship between energy consumption and economic growth is investigated in the form of VECM as empirically.

The models were estimated and analyzed using Eviews 3.0 software.

Theoretical basics of the relationship between energy consumption and economic growth

We live in economic and industrial development era and this development is increasing in the past decades. Energy is the most important commercial good with the greatest share in world trading. According to classic economists, the most important effective factors on economic growth considered in growth factors are including: Capital, technology and labor force, specialized and non-specialized, some new theories as growth biophysical or the theories raised by some neoclassic, energy factor is considered but its importance is not similar in various models. In growth biophysical model, energy is the only and most important factor of production as in accordance to first principle of thermodynamic, energy has fixed amount in nature. It can be compensated and turned into a matter and it is not destroyed. According to this theory, even specialized and non-specialized human resources are employed by dedicating great amount of energy in production and the goods produced in economy arise from the energy source applied from nature. Thus, in biophysical model developed by ecologist economists as Iyres and Nair energy is the main and only factor of production, labor force and capital are mediating factors needing energy for using. One of the most important studies of biophysical models is done by Kolivland and there is a causal relationship between energy consumption and GDP.

Energy is considered as one of the production factors beside labor and capital. Neoclassic economists as Berndt and Denison disagree with the ecologist economists. This group of neoclassic believes that energy by influencing labor force and capital affects economic growth and it has not direct effect on economic growth.

Review of Literature

Amade and Hosseinour (2001) in a study "the investigation of the relationship between energy consumption and economic growth and employment in various sectors of Iran economy", investigated energy consumption as an important factor of production with effective role on economic growth. Determining this relationship leads to clarification of policies of energy sector of the country. By autoregressive distributed lag (ARDL) and Error Correction Model (ECM), the short-term and long-term relationship between energy consumption and final consumption of various energy carriers were investigated as oil products, electricity, gas, economic growth and employment in various sectors of Iran economy during 1971-2003. The results showed that there was a one-way long-term and short-term causality relationship between final energy consumption and economic growth.

Abrishami and Mostafayi (2001) in a study "the relationship between economic growth and oil-products consumption" evaluated the relationship between economic growth and oil major products during 1959-1999. The results showed that in short-term, there is no Granger causality relationship between oil product consumption and GDP but in long-term, there is Granger causality relationship between products consumption and GDP. Also, in short-term, there is causality relation between production and inputs consumption and in long-term, there is causality relationship between GDP and products consumption.

Glasure (2002) investigated the relationship between consumption energy and real national income for Korean economy. He applied the annual data of the country during 1982-2011. The results of the study showed a two-way causal relationship between energy consumption and economic growth in Korea. Variance analysis showed that monetary expansionary and fiscal policies had positive effect on national income and energy consumption. The highest effect on national income and energy consumption in Korea was based on oil price.

Oh and Lee (2004) investigated the causality relationship between energy consumption and economic growth in Korea by annual data during 1970-1999. They used four-variable VECM including GDP variables, energy consumption, employment, capital to investigate the relationship between causality relationship between energy consumption and economic growth in short and long-term. The results of causality tests in short and long-term showed that there is a mutual causal relationship between energy

consumption and GDP in long-term. The relationship is from energy to GDP in short-term.

Narayan and Smyth (2004) investigated the relationship between electricity consumption, employment and real income for Australia. They used annual data during 1966-1999. Econometric model in this study was a three-item VECM model including per capita income, per capita energy consumption and industrial employment and three variables entered as endogenous in the model.

They found a long-term co-integration relationship between electricity consumption, employment and income. They showed that in long-term there is a one-way causal relation of employment and income to electricity consumption.

The present study by the investigation of various studies regarding the relationship between energy consumption and economic growth in Iran presented an acceptable model by VECM model.

Methodology and study model

In this study, the Granger causality relation between the variables is estimated by time series based on VECM. The error correction model states that dependent variable changes are based on deviation of long-term equivalence relation of (expressed by error correction part) and other explanatory variables. This model links short-term and long-term behavior of two variables.

The main model in this study is as:

$$Y_t = \beta_1 K_t + \beta_2 L_e + \beta_3 \Delta E_t + \beta_t T$$

Where,

Y_t: Economic growth

K_t: Capital

L_t: Labor force

E_t: Total energy consumption

As the study variables are time series and unit root test is done to avoid the spurious regression results, the co-integration degree of variables is determined. The study method for data analysis is VECM including two equations as followings:

$$\Delta y_t = \mu_1 + \sum_{i=1}^{k} \alpha_{1,k} V_{k,t-p} + \sum_{s=1}^{\rho} \gamma_{1,s} \Delta Y_{t-s} + \sum_{s=1}^{\rho} \gamma_{2,s} \Delta k_{t-s} + \sum_{s=1}^{\rho} \gamma_{3,s} \Delta l_{t-s} + \sum_{s=1}^{\rho} \gamma_{4,s} \Delta E_{t-s} + \eta_{1,t}$$

$$\Delta E_t = \mu_2 + \sum_{i=1}^{k} \alpha_{4,k} V_{k,t-p} + \sum_{s=1}^{\rho} \rho_{1,s} \Delta Y_{t-s} + \sum_{s=1}^{\rho} \rho_{2,s} \Delta k_{t-s} + \sum_{s=1}^{\rho} \rho_{3,s} \Delta l_{t-s} + \sum_{s=1}^{\rho} \rho_{4,s} \Delta E_{t-s} + \eta_{2,t}$$

Δ : Determining the difference of each variable.

S: Lag length is obtained by Schwarz criterion.

γ : Indicates the causality relationship of the variables and it allows us for causality test of short-term and long-term of variables. For example, in short-term, if $\gamma 3,s, \gamma 2,s, \gamma 1,s$ are equal to zero, in short term energy consumption and labor force and capital are not granger-causes capital of economic growth. If coefficients $\rho 3,s, \rho 2,s, \rho 1,s$ are equal to zero, in short-term economic growth and labor force and capital are not Granger causality of energy consumption.

α : This coefficient indicates the rejection of dependent variables of long-term equilibrium.

$V_{k,t-p}$: Indicates error correction component. $\mu 2, \mu 1$ Intercept and P, K, S are lag length. The results are estimated by time series model of VECM.

Stationary test (unit root)

Using classic methods of econometric in estimation of model coefficients by time series is based on assumption that model variables are Stationary. Time series variable is stationary if mean, variance and autocorrelation coefficients are constant over time. If time series variables in model estimation are not stationary, as there is no significant association between model variables and it can have high determination coefficient R2 and achieves wrong inferences regarding the relationship between variables.

Augmaned dicky – fuler (ADF)

When there is correlation between the terms of above model error (U_e), in such condition model estimation by Ordinary Least Squares (OLS) doesn't lead to efficient estimation. To solve this problem, the model is completed by adding dependent variable lags, the equation is changed as:

$$\Delta y_t = (\rho - 1) y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + \varepsilon_t$$

Thus, ADF is obtained and it is auto regression of K degree. By observing the principle of less lags, the number of lags (k) should be as the auto correlation is eliminated.

Causality test and error correction model

Granger (1988) stated that in case of co-integration relationship between two variables, causality as minimum Granger is as one way or two-way between them. Although co-integration test can determine the presence or absence of Granger causality relation between the variables, it can not determine the direction of causality relationship. Engle and Granger (1978) stated that if two variables Y_t, X_t are co-integrated, there is a VECM between them. Thus, to investigate Granger causality relationship between the variables, VECM can be used. Error correction model states that dependent variable changes are based on long-term deviation (stated by error component) and the changes of other explanatory variables. This model linking the short-term and long-term behavior of two variables is stated as:

$$\Delta Y_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta y_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta X_{t-i} + \lambda \varepsilon_{t-i} + u_t \qquad -1<\lambda<0$$

Thus, error correction component $(\lambda \varepsilon_{t-i})$ in error correction model presents an extra path to investigate Granger causality relationship and this is ignored in Granger and Sims causality tests. If the investigated variables as stationary are first degree and co-integrated, using a vector self-explanatory model on first difference of variables, instead of using a vector error correction model to investigate the Granger causality relationship between the variables, due to deleting error correction component $X_{t-1} - \beta Y_{t-1}$, regression equation variance is increased. Thus, Wald statistics is biased. This causes wrong judgment about causality relation and besides determining the Granger causality relationship between the variables, VECM enables us we consider difference between short-term and long-term Granger causality.

Insignificance λ shows that there is no Granger causality relation in long-term between explanatory variables and dependent variables or the dependent variable is a weak exogenous variable and the insignificance of the sum of lags of explanatory variables shows that in short-term there is no Granger causality relationship between each of explanatory variables and dependent variable.

Insignificance of the sum of lags of each of explanatory variables with λ shows that in long-term there is no Granger causality relationship between each of explanatory variables and dependent variable.

Results and Discussion

Stationary test

In this study, to investigate Stationary of variables, unit root test of ADF is used and the results of the test are presented in the following Table.

Table 1 The results of unit root test of ADF in level with intercept

Variables	t-Statistic	Prob.	Test critical values 5% level	Results
LGDP	0.194	0.96	-2.981	Non-stationary
LE	-0.752	0.81	-2.986	Non-stationary
LK	0.091	0.95	-2.976	Non-stationary
LL	-0.582	0.85	-2.976	Non-stationary

According to the results of Table 1, all variables are non-stationary in level and intercept as calculation statistics of the above variables is less than the table statistics and null hypothesis of unit root test of ADF regarding unit root is supported. Thus, in the following, we investigated the variables by entering time series. The results are shown in Table 2.

Table 2 The results of unit root of ADF in level and intercept and time series

Variables	t-Statistic	Prob.	Test critical values 5% level	Results
LGDP	-2.59	0.23	-4.6	Non-stationary
LE	-2.6	0.23	-4.36	Non-stationary
LK	-2.58	0.24	-4.2	Non-stationary
LL	1.58-	0.57	-3.35	Non-stationary

According to the results of Table 2, entering time series and repeating unit root test of ADF doesn't make any change in Stationarity of non-stationary variables. Thus, in this stage, we do differentiating of non-stationary variables of unit root test and the results are shown in Table 3.

Table 3 The results of unit root test of ADF by once differentiation and intercept

Variables	t-Statistic	Prob.	Test critical values 5% level	Results
LGDP	3.694	0.022	-2.981	Stationary
LE	-3.457	0.03	2.986	Stationary
LK	3.491-	0.014	2.976	Stationary
LL	-7.790	0.024	-2.976	Stationary

According to the results of Table 3, all the non-stationary variables of the model are stationary by once differentiation but to determine whether the variables need time series variable or not, Stationary test is repeated by once differentiating and considering intercept and time series and the results are shown in Table 3.

Table 4 The results of unit root of ADF by once differentiating and intercept and trend

Variables	t-Statistic	Prob.	Test critical values 5% level	Results
LGDP	-3.59	0.002	-3.07	Stationary
LE	-3.6	0.03	-3.3	Stationary
LK	-4.33	0.05	-3.43	Stationary
LL	-7.62	0.000	-3.58	Stationary

Based on the results of Table 4, it can be said, all non-stationary variables are stationary by once differentiating and intercept and time series and the time series variable is not an important variable in Stationary of non-stationary variables.

Based on the results, it can be said all variables are stationary by once differentiating (or all are $I(1)$).

The results showed that there is mutual Granger causality relationship between economic growth and energy consumption. It is observed regarding other variables, there is a one-way relation between economic growth and capital (on behalf of capital) on economic growth. Also, there is a one-way association between economic growth and labor force from the side of labor force on economic growth.

Table 5 The results of wald test on short-term VECM, the investigation of short-term causality between economic growth and energy consumption

Dependent variable	Independent variable	Chi-sq.	Prob.	Causality
LGDP	LL	8.57	0.01	LL→LGDP
LGDP	LE	18.66	0.0001	LE→LGDP
LGDP	LK	9.47	0.0088	LK→LGDP
LL	LGDP	0.86	0.64	No causality relation
LL	LE	0.82	0.66	No causality relation
LL	LK	3.69	0.15	No causality relation
LE	LGDP	8.21	0.01	LGDP→LE
LE	LL	0.15	0.92	No causality relation
LE	LK	0.76	0.68	No causality relation
LK	LGDP	1.64	0.43	No causality relation
LK	LL	0.33	0.84	No causality relation
LK	LE	1.04	0.59	No causality relation

Determining optimal lag

One of the main stages in estimation of VAR model is selecting optimal degree of model. In selecting optimal degree of model, it is important that high degree is selected for test as it can be said optimal degree of model is not higher than this value. The highest value of Schwarz- Bayesian and Akaike show optimal degree of VAR model.

Table 6 Determining the number of optimal lags

HQ	SC	AIC	Number of lags
-2.919	-2.781	-2.974	0
-10.592	-9.903	-10.87	1
9.900-	-8.660	-10.40	2

Optimal degree of VAR model based on three criteria of Schwarz-. Bayesian, Henan Quinn and Akaike criteria is 1.

Co-integration

Co-integration test evaluates the long-term relationship between the variables and the long-term relationship of economic theories between non-stationary variables is investigated. To investigate co-integration, various tests are used. One of the methods is Johansen-Juselius. This method presents two likelihood tests to determine convergence vectors including trace test and maximal eigen-value test.

Estimating the long-term relationship and extraction of co-integration vectors by Johansen-Juselius method

In this method, to achieve long-term relation of variables, at first by two statistics of maximum eigenvalue and co-integration effect test and the number of co-integration relations are defined. In maximum eigen-value, null hypothesis "the lack of co-integration relation" and "a co-integration relation" and presence of one or less than one co-integration relation" to "two co-integration relations" and etc. are tested. The trace test evaluates the hypothesis "No co-integration relation" to "the presence of one or more co-integration relations" and the presence of one or less than one co-integration relation to "two or more co-integration "relations. If the statistics of test of these variables are greater than critical values at the level 0.05, H1 is supported and the number of co-integration vectors is obtained. In the next stage, normalization based on one of the variables is done.

Table 7 The test of determining the number of co-integration relations

Rank		Trace test $\lambda\, trace$		(Maximal eigen-value) $\lambda\, \max$	
H_0	H_1	Statistics	Critical value at the level 95%	Statistics	Critical value at the level 95%
0=r	r=1	89.220	40.175	63.630	24.160
r<1	r=2	25.585	24.275	17.965	17.800
r<2	r=3	8.220	12.320	7.750	11.225

The maximum eigenvalue ($\lambda\, \max$), trace test ($\lambda trace$) presented two co-integration vectors. In other words, two linear compositions of endogenous variables of GDP, energy consumption, labor force and capital are stationary. Table 8 shows the results of co-integration vectors.

Table 8 Co-integration vectors

Second vector	**First vector**	**Variable**
1.000	-0.119	GDP variable
-0.148	1.000	Energy
-0.040	-0.235	Capital
-0.585	-0.162	Labor force

As two co-integration and two normalized vectors were obtained, two long-term equilibrium relations are between two variables and based on the items, only the second vector has the expected consideration as in the second vector, there is positive relationship between energy variables, capital and labor force with GDP.

Among two co-integration vectors, a suitable vector should be selected. To do this, Bahmani-Oskooee, Bruke and errors square mean are applied. The obtained co-integration vectors are plotted for dependent variable and observed value of main variable and the closest vector to observed value is selected. According to chart 1, vector 2 is the closest vector to the observed value of GDP and $\sum e^2$ of Table (9) has the lowest value.

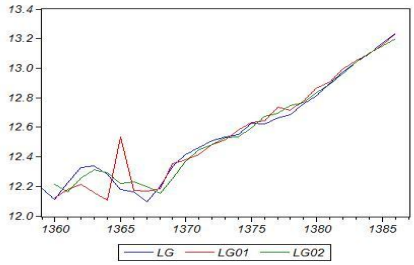

Figure 1 The vectors of dependent variable of GDP

The results of table are consistent with theory completely. Based on the presented results, it can be said one percent increase in final consumption of energy, labor force and capital lead to the increase of economic growth as 0.14, 0.58, 0.04.

Error correction model

The major fame of ECM is that short-term fluctuations of variables can be related to their long-term equilibrium values. If two variables are co-integrated, there is a long-term equilibrium balance between them. There are some non-equilibrium in short-term, these models are some partial equilibrium models in which by entering stationary residual, long-term relation, effective forces in short-term and the speed of achieving the long-term equilibrium values.

Table 9- The results of estimation are reflected in the following table:

Prob.	T statistics	Coefficient	Variable
0.03	-3.847	-0.080	Labor force
0.01	-4.126	-0.120	Capital
0.05	-3.253	-0.05	Energy
0.05	-3.283	-0.174	ECM
R-squared:0.66		F-statistic:14.08	
Adj.R-squared: 0.63			

If error correction coefficient is negative, it shows error correction speed and approaching long-term equilibrium. This coefficient shows that in each period, which

percent of non-equilibrium of dependent variable is adjusted and approaches long-term relationship.

In second vector ecm (-1) is equal to -0.17. Based on statistics t, it is significant with high confidence interval. Thus, there is a short-term relation among the model variables. Error correction component coefficient shows economic growth in each year as 17% is adjusted to long-term equilibrium. Thus, adjustment coefficient shows low speed of convergence to long-term equilibrium.

Summary and conclusion

Achieving major economic growth is always considered by economists in various countries. They always attempted to find the effective factors on economic growth and provide the conditions for high economic growth. The positive relationship between economic growth and energy consumption caused that the researchers investigate the effective factors on two items.

The present study aimed to search about the effect of energy consumption on economic growth and the effect of economic growth on energy consumption in Iran by time series during 1971-2009. According to the economic theories, it is expected that GDP is dependent upon existing variables of capital, labor force and energy consumption. To study stationary variables, ADF unit root test is used and the results of the study showed that all variables in level and intercept are non-stationary and null hypothesis of unit root test of ADF regarding unit root test is supported. Then, all non-stationary variables are stationary by once differentiating and with intercept and time series and the time series is an important variable in stationary of non-stationary variables. Co-integration test supports a vector or long-term equilibrium relation (consistent with economic theory) among them. By obtaining error correction component, long-term equilibrium vector, short-term error correction equations and the relations between the variables are estimated. To investigate causality relation between economic growth and energy consumption, Wald test on short-term VECM is used. The results showed that there is mutual Granger relation. Regarding the other variables, the results showed that there is a one-way relation between economic growth and capital from capital on growth side. Also, there is a one-way association between economic growth and labor force from labor force on economic growth. Based on VECM, there is a mutual Granger relationship in long-term and short-term.

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