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The Relationship between Value-Added and Energy Consumption in Iran's Industry Sector

Morteza Raei Dehaghi, Mojtaba Molaahmadi, Seyed Mohammad Mirhashemi

Abstract**—**This study aimed to explore the relationship between energy consumption and value-added in Iran's industry sector during the time period 1973-2011. Annual data related to energy consumption and value added in the industry sector were used. The results of the study revealed a positive relationship between energy consumption and value-added of the industry sector. Similarly, the results showed that there is one-way causality between energy consumption and value-added in the industry sector.

Keywords**—**Energy consumption, economic growth, industry sector.

I. Introduction

ENERGY, as a driving force, has a special place in the manufacturing and service activities and generally plays an effective role in economic growth and development [1]. It is an important input in manufacturing of products and services and has a main role in supply and demand side of the economy. In demand viewpoint, energy has been regarded as one of the effective factors on consumers' decisions to maximize their favorability, and from supply side of the economy, it has a major role in economic growth and development of countries as well as enhancement of living standards aside from other production factors such as capital stock and labor force [2]. Two energy crises that affected the economic growth in 1970's, due to increased energy prices, have attracted the attention of policy makers towards saving policies in energy consumption. However, if energy consumption is the cause of economic growth, policies of decreasing energy consumption can affect the economic growth. Reduction of the economic growth will decrease production and employment [3]. Hence, given these issues, it is clear that explaining the basic relationship between two variables can help policy makers and economic planners execute developmental policies.

Iran, as a growing country, enjoys extensive energy resources and existence of large oil reserves, underground mines and the potential energy is one of the evidences of the growth model by exerting pressure on natural resources. Therefore, planning for energy consumption and production is very important. On the other side, considering the importance of the industry sector as one of the most important economic sectors, planning in the field of energy in this sector becomes more important. This study explores the relationship between energy consumption and economic growth in the industry sector in Iran. The present study is organized in five sections. Section II addresses literature review and Section III presents research methodology. Sections IV present results and finding and the last section contains discussion and conclusion.

Morteza Raei Dehaghi is Assistant Professor in the Department of Industrial Management, Dehagh Branch, Islamic Azad University, Dehagh, Isfahan, Iran, (e-mail: dr_mraeidehaghi@yahoo.com.ph)

Mojtaba Molaahmadi is aPhD Student in the Islamic Azad University, Dehagh Branch, Dehagh, Isfahan, Iran.

Seyed Mohammad Mirhashemi is a PhD Student of Economic Science, University of Shiraz, Shiraz, Iran.

II. Literature Review

In this section, a number of studies conducted in Iran and other countries are mentioned. Aside from the mentioned studies, other research studies have been carried out including that of [4]-[10] can be mentioned that each one has explored the relationship between energy consumption and economic growth through gathered data from different countries using different methods.

Behbudi et al. investigated the relationship between energy consumption and economic growth using annual time-series data of Iran's economy during the time period 1968-2006 by emphasizing its structural failure. Zivot-Andrews unit root test and Johansen Gregory Cointegration test were used to explore the long-term relationship between energy consumption and economic growth. Results of this study showed that there is a long-term relationship between energy consumption and economic growth considering its structural failure [11].

Fetres et al. explored the relationship between consumption of renewable and nonrenewable energies and economic growth using data of the selected developing countries during the time period 1980-2009 as well as the Panel unit root test, Panel cointegration test and least squares integration method. The results of this study showed that coefficient of long-term effectiveness of nonrenewable energy consumption is more than that of renewable energy consumption on economic growth [1].

Nikoueghbal et al. investigated dynamic causal relationship among variables of energy consumption growth, economic growth and carbon dioxide (CO_2) emission growth using dynamic panel data approach and GMM-SYS technique in long term and for three different income groups, i.e. less than average, higher than average and high income. The results revealed that there is one-way causal relationship between economic growth and energy consumption in all income groups. In addition, the causal relationship between economic growth and CO_2 emission growth showed that this relationship is positive in less than average income group while this relation is negative in higher than average and high income groups [12].

Sadeghi et al. explored the relationship between economic growth and energy consumption in MENA countries, using the gathered data from Middle East countries and North Africa during 1980-2009 utilizing the Generalized Method of Moments (GMM). The results indicated that there is a one-way causal relationship between energy consumption and GDP in the countries under study. Therefore, they concluded that production in those countries is affected by energy consumption besides production factors of labor force and capital stock and the increase of production level in the countries under study depends on energy consumption too. As a result, they pointed out that any policy leading to decrease energy consumption in such countries will have negative effects on economic growth [2].

Bozoklu and Yilanci investigated the causal relationship between energy consumption and economic growth in twenty OECD countries. They used Granger causality test to distinguish between short-term and long-term causality. The results of this test showed that there is short-term causality between energy consumption and GDP in Australia, Canada, Japan, Italy, Mexico, Netherlands, Portugal, England and the United States. Similarly, they concluded that there is a long-term one-way causality relationship between GDP and energy consumption in Belgium, Denmark, Germany, Italy, Japan, Netherlands, Norway and USA [3].

Dergiades et al. explored linear and non-linear causal relationship between energy consumption and performance of the economy in Greece using time-series data in 1960-2008. They used vector autoregression model and parametric and non-parametric tests. According to the results, there was a one-way causal relationship between energy consumption and economic growth according to parametric and non-parametric tests [13].

Smiech and Papiez explored the causal relationship between energy consumption and economic growth considering energy policies in the European Union member states. To this end, they used the data of 1993-2011 and Bootstrap panel causality. The results of causal relationship between energy consumption and economic growth obtained differently for different groups. There was no significant causal relationship in the group with medium and low energy intensity while a significant relationship between energy consumption and economic growth was obtained in countries with higher energy intensity [14].

Lin et al. investigated the causal relationship between energy consumption and economic growth in South Africa. They employed Bootstrap non-parametric approach and Granger causality test. The results revealed that there is one-way causality between energy consumption and economic growth. Thus, they concluded that saving policies in energy consumption can have a negative effect on economic growth [15].

Omri and Kahouli investigated causal relationship between energy consumption, foreign direct investment and economic growth by means of dynamic simultaneous equation models. Data of 65 countries during 1990-2011 were used. It was concluded that there was mutual causal relationship between energy consumption, foreign direct investment inflow and economic growth in high income countries [16].

III. Methodology

Vector autoregression method (VAR) is one of the methods used in exploring relations among economic variables. One of the flaws of this method is that it assumes all variables in the model are stationary but it is not true in reality. When variables (or even one of them) in the model are not stationary, vector error correction model can be a good substitution for vector autoregression model. It is a model to link short-term relations to long-term relations based on a VAR model with convergence characteristics. Thus, vector error correction model and impulse response function were used in this study.

Data of 1973-2011 were used for model estimation and the intended data were obtained from the published information by the World Bank. Data analysis was carried out by means of Eviews 6 software.

IV. Results and Findings

A. Unit Root Test Variables

Stationary of variables was examined using Augmented Dickey–Fuller test. Table I shows the results of this test. For choosing the number of optimal lags, Akaike criterion was selected. Both variables do not reject the null hypothesis regarding that variables have unit root but variables with one time differentiation reject it, i.e. DLY that shows first-order difference of logarithm of value-added in the industry sector and DLEC that shows first-order difference of logarithm of energy consumption in the industry sector. Thus, both are first-order stock variables.

TABLE I
Results of Unit Root Test of Variables

Variable	Trend and intercept	Dickey–Fuller test statistics	Critical value*
LY	Trend and intercept	-1.648	-4.262
LEC	Trend and intercept	-4.351	-4.252
DLY	Trend and intercept	-4.543	-4.262
DLEC	Trend and intercept	-3.521	-4.219

Critical values are at the confidence level 99%.

B. Determination of the Number of Long-Term Convergent Vector

Johansen convergence method based on trace (λ_{trace}) and maximum eigen value (λ_{max}) were used to determine the number of convergent vectors (r). The results of maximum eigen value test and trace are shown in Table II. Given the results of Table II, both λ_{trace} and λ_{max}test statistics confirm existence of convergent vector, because the null hypothesis in relation to nonexistence of a convergent vector is rejected by both test statistics but the hypothesis related to existence of more than one convergent vector is not rejected. Therefore, it can be stated that the intended variables are convergent (co-integrated).

TABLE II
RESULTS OF MAXIMUM EIGEN VALUE TEST AND TRACE TO SPECIFY CONVERGENT VECTOR

	Probability	Critical value	Test statistic	Alternate hypothesis	Null hypothesis
λ_{max}	0.027	19.387	21.170	r=1	r=0
		12.517	4.255	r=2	r<=1
λ_{trace}	0.056	25.872	25.425	r=1	r=0
	0.704	12.517	4.255	r=2	r<=1

Critical values are at the confidence level 99%.

C. Estimation of Error Correction Model

Error correction model relates short-term fluctuations of variables to their long-term equilibrium values and considers short-term dynamic reaction of the variables. In this model, error correction coefficient that is the regression error term of long-term stationary model ($\hat{u}_t$) shows the speed of returning to equilibrium position. Tables III and IV show error correction equation for variable LY and error correction equation for LEC, respectively. Akaike criterion was selected to determine the number of lags in model estimation.

TABLE III
ERROR CORRECTION EQUATION FOR THE VARIABLE LY

Variables	Coefficients	Probability level
Intercept	0.045	0.028
DLY (-1)	0.036	0.000
DLY (-2)	0.246	0.045
DLEC(-1)	0.328	0.022
DLEC(-2)	0.155	0.015
CM (-1)	-0.218	0.039

Coefficient CM in Table III shows the adjustment speed and illustrates that 21% of imbalance is adjusted in each period that shows the average speed of adjustment in the model. Also, coefficients related to lag one and two of first-order difference of energy consumption logarithm in the industry sector reveal that energy consumption in short-term has had a positive and significant effect on value-added in the industry sector. Coefficient CM in Table IV shows the adjustment speed and illustrates that 35% of the imbalance is adjusted in each period. It shows high speed of adjustment in the model. Also, coefficients related to lag one and two of first-order difference of value-added logarithm in the industry sector reveal that value-added of the industry sector do not have a positive and significant effect on energy consumption in the industry sector.

D. Impulse Response

One of the uses of VAR model was to explore response of model variables to the shocks in each variable. As it is clear in the model, one-standard-deviation shock in value-added of housing sector has increased energy consumption in the industry sector and this effect remains stable after 4 periods. In addition, model shows response of the value-added variable in the industry sector to one-standard-deviation shock in energy consumption. Therefore, one-standard-deviation shock in energy consumption increases value-added in the industry sector and then its effect inclines towards zero after 4 periods.

TABLE IV
ERROR CORRECTION EQUATION FOR THE VARIABLE LEC

Variables	Coefficients	Probability level
Intercept	0.072	0.017
DLY (-1)	-0.085	0.105
DLY (-2)	-0.017	0.102
DLEC(-1)	-0.046	0.133
DLEC(-2)	-0.036	0.128
CM(-1)	-0.357	0.039

E. Granger Causality Test

Table V shows the results of Granger causality test between value-added logarithm and energy consumption logarithm in the industry sector.

TABLE V
RESULTS OF GRANGER CAUSALITY TEST AMONG THE VARIABLES

Hypothesis	Test statistic F	Probability
Energy consumption logarithm is not the Granger reason for value-added in the industry sector.	3.410	0.045
Value-added logarithm is not the reason for Granger energy consumption in the industry sector.	0.602	0.553

As it is obvious in Table V, the assumption that energy consumption logarithm is not the reason for value-added in the industry sector that is rejected at level 5%. However, the assumption that value-added logarithm is not the reason for energy consumption in the industry sector is not rejected at level 5%. Thus, it can be stated that there is a one-way causal relationship between energy consumption and value-added in the industry sector in Iran. As a result, the growth hypothesis is confirmed in Iran and the industry sector considering the obtained results. It means that energy consumption as a manufacturing input will lead to economic growth in the industry sector.

V. DISCUSSION AND CONCLUSION

Given the importance of energy as one of the production inputs and policy making in the energy sector as well as the importance of industry sector in economy of each country especially Iran, the relationship between energy consumption and value-added in the industry sector was analyzed in this study. Thus, Augmented Dickey–Fuller test, Johansen Juselius Cointegration test, vector error correction model, and Granger causality test were used. The data related to energy consumption and value-added in the industry sector were employed for 1973-2011. The results of unit root test showed that variables were not stationary but their first order difference was stationary. Johansen Juselius Cointegration test confirms a long-term balanced relationship among the variables. Vector error correction model showed that there is a positive and significant relationship between energy consumption and value-added in the industry sector in short-term. In addition, results of impulse response functions confirm the positive effect of energy consumption on value-added in the industry sector. Finally, Granger causality test revealed that there is one-way causal relationship between energy consumption and value-added in the industry sector. Thus, the growth hypothesis was confirmed for the industry sector in Iran. Results of this study confirm the results of studies done by [11], [6], some results of [13]-[15] are different from the results obtained by [3], [16] and [2]. This difference can be due to use of different methods and different data.

Given the obtained results, it can be concluded that saving policies in energy consumption can have a negative effect on economic growth. Therefore, it is necessary to act cautiously in execution of any saving policy in energy consumption so that implementing such policies does not have contraction effects on economic growth. Adopting suitable policies to enhance productivity and optimal use of energy carriers have more priorities than the policies based on quantitative decreases in consuming these carriers. In this regard, adopting appropriate policies of the supply and demand sides of energy, discarding old machines, motors and equipment and replacing them with new machines especially in energy-intensive sectors, i.e. domestic, commercial, transportation, industry and electricity generation seemed to be a suitable policies.

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