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# Investigation of the Relationship Between Energy Consumption and Economic Growth of Industry Sector in International Law

***Abstract: -*** Efficient exploitation of energy resources and saving energy carriers, particularly in the industry sector are crucial cases. Therefore, identification of the type of relationship between energy consumption and growth in industrial products is necessary to achieve this goal. Regarding the close relationship between energy consumption and the economic growth of the industry sector in International Law, this study investigates the long-run relationship using the Autoregressive Distributed Lag (ARDL) model. Also, it examines the Granger causality between energy consumption in the industry sector and the economic growth of this sector during 1981-2017. The results of the ARDL model indicate that all coefficients are significant at the confidence level of 95%. The results show that employment in the industry sector has a positive and significant effect on the economic growth of the industry sector during the long term in Iran. Energy consumption in the industry sector has a positive and significant impact on the economic growth of the industry sector in the long term in Iran. Also, the capital of the industry sector has a positive and significant impact on the economic growth of the industry sector in the long term in international law.

Moreover, results suggest that energy consumption of the industry sector is not Granger causality for the economic growth of this sector, and this hypothesis is rejected. However, the second hypothesis (economic development of the industry sector is not the Granger causality for energy consumption) cannot be rejected. There, there is unidirectional Granger causality from energy consumption of the industry sector towards economic growth of this sector. Considering the unidirectional Granger causality from energy consumption in the industry sector towards the economic growth of this sector, it is concluded that an increase in energy consumption drives economic growth.

***Keywords:*** Energy Consumption, Economic Growth, Industry Sector, Employment, Capital , International Law

## I. INTRODUCTION

As a growing country having many energy resources large oil reservoirs, numerous underground mines, and energy potential, Iran is an example of a growth model with pressure on the natural resources. Therefore, it is highly important to have a precise plan for energy consumption. This plan can effectively contribute to determining energy sector policies due to the close relationship between energy consumption and economic growth (Arman & Zare, 2005).

As a driving force, energy is a substantial factor in most manufacturing and service activities. Since Gross Domestic Production (GDP) growth is the main pillar of the economic growth process, energy plays an effective role in the economic growth and development of the country. Many studies have investigated the relationship between energy consumption and energy growth and the determination of causality between these two variables since the incident of oil shocks during the 1970s and the appearance of severe oscillation in the price of energy carriers. In addition to energy price oscillations and energy resource scarcity, environmental issues that countries deal with worldwide are other important factors that highlight the necessity of examining the relationship between production and energy consumption. Many treaties and contracts, including the Kyoto and Montreal Protocols, have been signed by many countries to alleviate the emission of greenhouse gases such as $CO_2$. It should be noted, nevertheless, emission rate of these pollutants has a direct relationship with the energy consumption of countries, and energy is considered a production factor and driving engine of economic growth. Therefore, a contradiction appears in the goals of countries if pollutant emission control can reduce their economic growth. Because Iran is a growing country having many energy resources and large oil reservoir, numerous underground mines, and energy potential, this country is an example of a growth model with pressure on the natural resources. Therefore, it is highly important to have a precise plan for energy consumption (Mohammadi et al., 2012).

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On the other hand, industry is one of the significant sectors in the economy of all international law. Industry leaves considerable impacts on the social, political, and economic relationships inside a country and between countries. Hence, most communities aim to pay attention to the growth and development of this sector. Thus, developing countries, including Iran have followed economic growth and development through the development of the industry sector and spending money to solve its problems and create new industries (Izadi & Izadi, 2011).

Therefore, many economic analysts have paid attention to the relationship between economic growth and consumption of various energy carriers such as oil products, natural gas, and electricity as important production factors. Iran is a growing country with many energy resources, a large oil reservoir, numerous underground mines, and energy potential. Accordingly, Iran has a proper and outstanding situation rather to other countries in international law. These huge resources can play an effective role as an important factor in the economy if they are utilized optimally and suitably. Hence, Iran is an example of a growth model with pressure on the natural resources as a growing country having many energy resources and energy potential. Therefore, the determination of quantity and quality of the relationship between energy consumption and economic growth can be effective in adopting energy sector policies. The government in Iran has chosen the economic policy of limiting energy consumption, especially consumption of oil products such as gasoline, and the problems caused by gas pressure decline like gas disconnection in different provinces and lower power generation in the factories where natural gas is the main fuels have made many problems in Iran. Thus, determining the relationship between energy consumption and economic growth in the industry sector can be an appropriate instruction for policymakers in the energy and economy sectors of the country in the industry field. The importance of energy in the process of manufacturing various products on the one hand and energy scarcity on the other hand require more attention from economic activists to more efficient utilization of this factor. Furthermore, the difference between the structures of the countries due to their different energy resources and their various technical and technological performances in energy resource use makes it crucial to investigate the relationship between energy consumption and economic growth as a valuable topic. This study tries to investigate the relationship between energy consumption and economic growth in the industry sector of Iran by using the ARDL model in international law This study also examines the causality between the energy consumption of the industry sector and the economic growth of this sector based on the Granger Linear Causality Test (1969).

**Theoretical foundations**

**The relationship between economic growth and energy consumption**

Energy carriers' demand can be expressed based on two aspects: the demand of energy carriers is considered as the final product by consumers and production input by the producers. According to the consumer behavior theory, which is based on the utility maximization mechanism considering the budget constraint; the demand rate for energy carriers also will be a function of price and income like the demand for other consumer goods. In terms of another aspect based on the theory of the firms, a manufacturing firm can maximize the profit or maximize the product with a certain cost and or minimize the cost with a certain amount of production. Therefore, the demand rate for energy carriers as production input can be a function of input price, price of other inputs, and amount of production (Molaei et al., 2015).

Energy price changes affect economic activities in two ways. First, it occurs through the impact on aggregate demand, which changes appear in the short term. The term demand has been used because the supply capacity of an economy (capital abundance, labor force, and raw materials and their productivity rates) experiences a minor change within the short term. Therefore, severe oscillations in the energy price may result in unemployment and low efficiency of production factors expected for the energy sector. The second way through which, the impulse caused by energy prices can affect the economy is seen in the impact of the supply side on the economy or through the impact on the production capacity of the economy. Because capital abundance and its allocation, labor force, raw materials, and production efficiency grow slowly, the impact on the supply side is slower, and it is felt within a longer time interval so that the impact on the supply side appears as a slower economic growth instead of an acute economic recession. However, it is not clear that the impacts of the price shock of energy on the supply side are such an important case. Some economists indeed believe that the energy sector's contribution to Gross National Production (GNP) is so minor that price shocks of energy have a highly less impact on economic growth. It is now asked whether energy price shocks can affect the economic activity on the supply side of the economy and finally on the economic growth. The impact on productivity growth is the most important channel through which, energy price shocks can affect the supply side. Many economic analyses on the impacts of oil shocks with one production function have confirmed that products depend on the capital, labor force, and energy data. An endogenous decline in energy supply leads to a direct reduction in product by decreasing productivity rate. It also indirectly results in a decline in wages and a subsequent decrease in labor force and production. According to assessments, the increase in the energy price of the industry sector over the years of 1990s made oil-consuming countries save energy and consume less energy. A reflection on the economic structure of Iran and other oil-exporting countries indicates their severe dependence on the income raised from oil sales. Hence, it is guessed that many shocks imposed on the economy are rooted in the oil shock. The economic relations and features of these countries indeed are shaped in a way that any type of oil shock, either price shock or income shock of oil, not only leaves direct impacts on the GDP but also indirectly changes the monetary base, trade balance, and government budget balance through which, some monetary and actual flows and implications occur in the economy. In the first stage, the direct impact of oil price changes on economic growth is similar in both oil-exporting and oil-importing countries, so that oil price changes- especially its increase- result in inflationary conditions in the economy that, in turn, can affect the changing trend of interest and investment rates. However, the indirect impact of oil price change on GDP may occur through the budget balance channel. In this case, oil is inserted into the exports and imports function of both oil-exporting and oil-importing countries as an important export and import product for the industries of the first and second types of countries, respectively. Hence, oil price changes affect their import and export impulse functions, which subsequently affect the trade balance and GDP (Bahmanyar & Fotros, 2012).

The access rate of economic firms to production factors affects their production level, and each production factor allocation has different impacts on the production levels of goods and services. It is clear that firms' production determines the aggregate production, and ultimately the economic growth level. Hence, production factors affect economic growth by changing firms' production. Thus, the formula below can be written if the production of each firm is considered as a function of various factors:

$Q=f(x_i)$

where Q represents aggregate domestic production and $x_i$ indicates various production factors. Also, it is assumed there is a direct relationship between utilization of these production factors and production level indicating that any increase in these inputs would increase the production. In other words, the demand for production factors will rise along with economic growth.

One factor used as a production factor is energy and its different shapes with a special role in most manufacturing and service activities. Energy also plays a significant role in the economic growth of the countries. In neoclassic growth models, capital and labor force are the only and most important factors affecting economic growth. However, the energy factor has been considered with a different importance rate in the new growth theories. Stern and Kelond (2004) have investigated the factors that can affect the relationship between energy consumption and economic activities and expressed the general form of a production function below by using studies on the neoclassic production function:

$(Q_1,\ldots,Q_m)=f(A,X_1,\ldots,X_n,E_1,\ldots,E_P)$

where $Q_i$ indicates various economic productions, including manufacturing and service products, $X_i$ represents production factors such as capital and labor force, $E_i$ is the energy factor, such as oil, and A shows the technological status and productivity index. In this function, the relationship between energy and aggregate production (GDP) is affected by some factors, including substitution between energy and other factors, technological change (changes in A), variation in energy factor composition, change in manufacturing product composition, and change in the date and composition of factors. Therefore, the formula below is written if production is considered as a function of labor (L), capital (K), and different energy shapes (E):

$Q=f\,(L, K, E)$

There is a direct relationship between the utilization of these inputs and the production level. It means that an increase in each considered input leads to an increase in production. In other words, when a country experiences production growth then an increasing pressure is imposed on the resources. In this case, demand for various shapes of energy increases. Hence, the relationship between economic growth and energy carriers' consumption has received great attention from economic analysts.

Capital and labor force, including skilled and nonskilled labor, are the most important factors affecting the economic growth that are considered in the growth functions. Energy factor has been also imported into the new growth theories, but its importance is not similar in various models. Stern (1993), quoted from Ayres and Nair (1984), expresses energy is the only and most important factor of growth in the biophysical model of growth. Labor force and capital are intermediate factors that require energy to be utilized. Quoted from neoclassic economists such as Berndt (1987) and Denison (1979, 1985), Stern (1993) also explains that energy indirectly affects economic growth by affecting the labor force and capital without any direct effect on economic growth.

In addition to labor and capital inputs, energy is now considered one of the significant production inputs in macroeconomic discussions, and production is a function of labor, capital, and energy inputs. Also, it is assumed that there is a direct relationship between the use of these inputs and the production level. On the other hand, energy consumption is a reverse function of its price, and energy price change leaves a substantial effect on energy consumption, and subsequently on the GNP (Maleki, 1999).

If it is assumed that labor is variable while other production factors remain fixed in determining aggregate supply in the macro economy, an increase in energy price and subsequent reduction in its demand lead to a decline in labor productivity, which results in a shift of labor demand curve towards the left that decreases employment rate. When the employment rate is reduced, the national product is decreased and prices are increased. In this case, the aggregate supply curve shifts towards the left. Energy price shock also can increase the general level of prices by increasing production costs. In this case, this shock reduces aggregate demand components, shifts the aggregate demand curve in the macroeconomy toward the left, and decreases the real national product (Ahmadian, 2009).

The viewpoints of several theorists are reviewed for further analysis of the relationship between energy consumption and economic growth. Pindyck (1979) believes that the effect of energy price on economic growth depends on the role of energy in the production structure. In his opinion, in industries where energy is used as an intermediate input in production, its price increase (decline in energy consumption) would affect the production rate and decrease the national production. He employs the total cost function to indicate this case and does his analysis based on the production cost elasticity relative to the energy price. If capital and labor are considered energy substitutions, any increase in energy price leads to more utilization of two capital and labor factors.

Moreover, an increase in production costs caused by higher energy prices would change the allocation of production factors, and the relative contribution of production resulting from two labor and capital factors will be increased. Quoted from Berndt and Wood (1975), Douglas (1991) explains that total energy in the production function is a production factor that has a weakly separable relationship with labor. In their suggested production function, energy must be integrated with the capital at first, and then the outcome of the combination creates a product after being integrated with the labor factor. Therefore, energy consumption would affect the final production of capital without affecting the final production of labor.

According to the neoclassic growth model, capital and labor force are the most important factors that affect economic growth. Stern and Cleveland (2004) explain that energy growth is the most important and single factor of growth in the biophysical model. Since all manufacturing processes need energy, energy is the underlying factor in the manufacturing process. In their opinion, labor force and capital are intermediate factors that need energy to be used. Stern and Cleveland (2004) have investigated those factors that can affect the relationship between energy consumption and the activity of economic sectors by using literature on the neoclassic production function. They present the general form of a production function as follows:

$(Q_1, Q_2, \ldots, Q_n) = F(A, X_1, X_2, \ldots, X_n, E_1, E_2, \ldots, E_n)$

where $Q_i$ represents outputs of various economic sectors (products manufactured in the industry, service, and other sectors), $X_i$ indicates production factors (capital, labor force, etc.), $E_i$ shows energy factors (carriers) (oil, gas, and other products), and A indicates technological status as the total productivity index of production factors.

In this equation, the following factors can affect the relationship between energy and value-added of the industry sector, which is the objective of the present study:

- Substitution between energy and other factors; for instance, the substitution of capital factor instead of energy within the long-term resulting from the increase in the price of energy carriers
- Technological changes (change in A)
- Change in energy carriers' composition
- Change in manufactured product's composition
- Change in the rate and composition of production factors.

**Background**

Mehrara et al. (2011) studied the relationship between energy consumption and economic growth in 11 oil-exporting countries by using a unit root test and cointegration analysis with panel data. The results show a strong unidirectional causality from GDP per capita towards energy consumption per capita in oil-exporting countries.

Emami and Adibpour (2009) examine the asymmetric effects of oil shocks on output. Their results showed that the effect of oil shocks on the output is asymmetric within the short-term and long-term, so that the effect of positive shocks is higher than negative shocks within the short-term, while the effect of negative shocks is higher than positive shocks within the long-term. Moreover, the effect of positive shock on the output is enhanced through time and negative shocks.

Khalilpour (2006) studied the relationship between energy consumption and economic growth in Iran. The results of this study confirm a positive relationship between total energy consumption and economic growth, as well as a relationship between energy intermediary demand and economic growth in Iran. Also, there is a negative relationship between the final demand for energy and economic growth in Iran. The results mentioned above are confirmed by the results of model estimation using two techniques of time variation and adding human capital variables as a factor affecting economic growth.

Zhixin and Xin (2011) carried out a study titled "Causal Relationship between energy consumption and economic growth" using data from Shandong Province from 1980 to 2008 to examine the relationship between two variables of energy consumption and economic growth. To examine the relationship between economic growth and energy consumption, Granger Causality and Cointegration Tests were used in this study. The results show there is a long-term relationship between energy consumption and economic growth, and a bidirectional causal relationship exists between them.

Apergis and E. Payne (2011) conducted a study unlike previous studies on renewable energy consumption and growth and tested the relationship between renewable and non-renewable energy consumption and economic growth for 80 countries within the framework of a multivariate panel for the 1999-2007 period. The results of the error correction model in this study reveal the directional causality between renewable and nonrenewable energy and economic growth within both short-term and long-term periods. There is also a negative bidirectional causality between renewable and nonrenewable energies regarding the substitution between these two resources.

Menegaki (2011) conducted an empirical study on the relationship between economic growth and renewable energy within the framework of the multivariate panel for the 1997-2007 period in 27 European countries. The Panel Error Correction Model does not confirm any of the short-term and long-term Granger causality from renewable energy consumption towards economic growth; therefore, there is little evidence for the neutrality hypothesis. This result confirms the secondary role of renewable energy consumption in determining GDP in Europe.

## II. MATERIALS AND METHOD

### Model specification

ARDL approach is done within two stages. The long-term relationship between studied variables is tested in the first stage. In this case, when the sum of estimated coefficients related to lags of the dependent variable is less than 1 then the dynamic pattern tends towards the long-term equilibrium. Null and opposite hypotheses are defined below to detect long-run cointegration in the model. Therefore, a cointegration test of the hypothesis should be done:

$$\{H_\circ : \sum_{i=1}^{p} a_i - 1 \geq 0$$

There is no long-run cointegration between variables of the model

$$\{H_1 : \sum_{i=1}^{p} a_i - 1 < 0$$

There is long-run cointegration between variables of the model

The quantity of t-value is measured based on the long-run cointegration hypothesis test:

$$t = \frac{\sum_{i=1}^{p} \hat{a}_i - 1}{\sum_{i=1}^{p} S\hat{a}_i}$$

where $\sum_{i=1}^{p}\hat{\alpha}_i$ statistic is the sum of coefficients of lagged variables related to the dependent variable that appears on is right side of the equation and indicates the sum of standard deviations of these coefficients. If the absolute value of measure quantity is greater than the critical value provided by Banerjee, Doladl, and Mestre at the considered confidence level, $H_0$ is rejected, so there is a long-run equilibrium relationship between variables of the model (Hooshmand et al., 2008).

The model below is employed in this study to investigate the relationship between energy consumption of the industry sector and the economic growth of this sector:

LIGDP= F (IL, LIC, IEN)

where,

LIGDP: logarithm of GDP in the industry sector of Iran based on fixed price of 1997

IL: logarithm of employment in the industry sector of Iran

LIC: logarithm of capital inventory in the industry sector of Iran based on fixed price of 1997

IEN: logarithm of final consumption of total energy of various energy carriers, including oil, gas, and power products (based on the million barrels of crude oil) in the industry sector of Iran. Final energy consumption includes only that part of the energy that is consumed not that part of the energy that entered the energy conversion process and converted to other energy carriers.

The statistical data used in this study are time-series, and the studied period is from 1981 to 2017. The econometrics model used in this study is the ARDL model.

## III. RESULTS AND DISCUSSION

The Augmented Dickey-Fuller test was used to test the reliability of variables. The results of the Dickey-Fuller test indicate the stationary state of energy consumption (IEN) at the level, and the nonstationary state of economic growth variables of the industry sector (LIGDP), employment of the industry sector (IL), and capital inventory of industry sector (LIC). According to Table 1, all variables-except for energy consumption (IEN)- are cointegrated from a first degree or I(1).

**Table 1. Results of reliability test on variables based on the Augmented Dickey-Fuller (ADF) test**

| **Variable** | **Level** | | | | **First-order differentiation** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Computational value of ADF** | **Critical value of 1%** | **Critical value of 5%** | **Critical value of 10%** | **Computational value of ADF** | **Critical value of 1%** | **Critical value of 5%** | **Critical value of 10%** |
| LIGDP | 1.5104 | 3.6155 | 2.9411 | 2.6090 | 4.6756 | 3.6155 | 2.9411 | 2.609 |
| IL | 2.0627 | 3.6104 | 2.9389 | 2.6079 | 5.1241 | 3.6155 | 2.9411 | 2.6090 |
| LIC | 0.2197 | 3.6104 | 2.9389 | 2.6079 | 4.3371 | 3.6104 | 2.9389 | 2.6079 |
| IN | 3.7658 | 3.6055 | 2.9369 | 2.6068 | - | - | - | - |

**Source: Research Findings**

One of the important advantages of ARDL over other cointegration methods is its ability to estimate long-term and short-term relations under the conditions that even variables of the model are not reliable from zero-order and reliable from one-order. ARDL model also provides efficient and consistent estimates.

In this stage, the dynamic ARDL model or lags determined by the Schwartz-Bayesian criterion are estimated to ensure a long-run relationship. This criterion gives lag one to the export of the industry sector, lag zero to the output of the industry sector, and lag 2 to the real exchange rate. After the variables of the model are determined, the results of model estimation through the ARDL model are obtained as reported in the Table below:

**Table 2. Results of conditional convergence test of dynamic ARDL(2,3,0,3) model**

| Variable | Estimated coefficient | SD | t-value (Prob.) |
|---|---|---|---|
| LIGDP(-1) | 0.447959 | 0.176245 | 2.541679(0.0173) |
| LIGDP(-2) | 0.502995 | 0.163578 | -2.502949(0.0189) |
| IL | -2.05E-09 | 3.29E-08 | -0.062184(0.9509) |
| IL(-1) | -2.61E-08 | 4.77E-08 | -0.5474090(0.5888) |
| IL(-2) | 2.06E-09 | 4.87E-08 | 0.042282(0.9666) |
| IL(-3) | -4.02E-08 | 3.35E-08 | -1.200342(0.2408) |
| IN | 0.000175 | 3.28E-05 | 5.356247(0.0000) |
| LIC | 3.95E-06 | 2.11E-06 | 1.874910(0.0721) |
| LIC(-1) | -5.56E-06 | 4.35E-06 | -1.278581(0.2123) |
| LIC(-2) | 7.64E-06 | 4.35E-06 | 1.755883(0.0909) |
| LIC(-3) | -6.00E-06 | 2.35E-06 | -2.558604(0.0167) |
| C | 4.239343 | 0.799084 | 5.305254(0.0000) |
| | | | |
| $R^2$= 0.994 | $\bar{R}^2$ = 0.992 | DW= 2.14 | F= 430.7624(0.000000) |

**Source: Research Findings**

The long-run relationship presence must be examined first. Now, non-cointegration between variables of the model is assessed based on the obtained results. The considered t-value for doing this test is measured as follows:

Because the absolute value of this rate (-3.0383364) is less than the critical value of Banerjee, Doladl, and Mestre Table (-3.27), the null hypothesis about the lack of long-run relationship is confirmed, so there is a long-run relationship. After ensuring the long-run relationship, cointegration is estimated with the ARDL model with certain lags. The results of long-run relationship estimation are reported in Table 3.

**Table 3. Results of the estimated long-run model of ARDL(1,0,2)**

| Variable | Estimated coefficient | SD | t-value (Prob.) |
|---|---|---|---|
| IL | 0.004512 | 0.000000 | -2.583258(0.0158) |
| IN | 0.000181 | 0.000013 | 13.654322(0.0000) |
| LIC | 0.006327 | 0.000000 | 0.154414(0.0084) |
| C | 4.368630 | 0.013292 | 328.659923(0.0000) |

**Source: Research Findings**

All coefficients are significant at the confidence level of 95%. The coefficient of the industry sector's employment equals 0.004512 which indicates a positive and significant effect of the industry sector's employment on the economic growth of the industry sector within the long term in Iran. It means a 1% increase in the employment of the industry sector leads to a 0.004512% increase in the economic growth of the industry sector. The coefficient of energy consumption of the industry sector equals 0.000181, which shows a positive and significant effect of energy consumption of the industry sector on the economic growth of the industry sector within the long term in Iran. It means that a 1% increase in energy consumption of the industry sector leads to a 0.000181% increase in exports of the industry sector. Ultimately, the coefficient of the industry sector's capital equals 0.006327, which shows a positive and significant effect of the industry sector's capital on the economic growth of the industry sector within the long term in Iran. It means that a 1% increase in capital of the industry sector leads to a 0.006327% increase in economic growth of the industry sector.

The first step for the estimation of the vector error correction model (VECM) is determining the proper lag for the differentiation of variables in the model. However, the number of VECM's lags in the differentiation of variables is related to the number of level lags of variables in the VAR model. Hence, when one knows the number of lags in this model then one can identify the number of variables' differentiation lad in the VECM model.

Various criteria, including Likelihood Ratio (LR), Akaike (AIC), Schwartz Bayesian (SBC), and Hannan-Quinn (HQC) are used to determine the number of optimal lags. According to the mentioned points, optimal lag is determined based on the AIC, SBC, and HQC. SBC usually uses fewer lags, so the number of optimal lags is chosen based on the SBC in this research in which, lag 1 is the optimal lag in this model.

**Table 4. Determining the lag based on three criteria of AC, SBC, and HQC**

| **Lag** | **LR** | **AIC** | **SBC** | **HQC** |
|---|---|---|---|---|
| 0 | NA | -17.75937 | -17.46079 | -17.65224 |
| 1 | 470.3821 | -30.42017 | -28.03147* | -29.56312 |
| 2 | 8.50390* | -31.38668 | -26.90786 | -29.77972* |
| 3 | 48.44802 | -31.66492* | -25.09598 | -29.30804 |

**Source: Research Findings**

Because the optimal lag of the model equals 1, the lag of variable differentiation will equal 1 in the VECM model. Cointegration between a set of economic variables provides the statistical base for using VECM. These models that link short-term oscillations of variables to their long-term equilibrium values are indeed a kind of partial adjustment model that consists of stationary residues with a long-run relationship as the independent variable. These models are used to measure the effective factors in the short term and the velocity of approaching long-run equilibrium values. In this step, modification of short-run non-equilibriums in economic growth towards long-rum equilibrium is examined based on the VECM model. The coefficient of the VECM term indicates how many percent of short-run non-equilibrium of economic growth is modified to reach long-run equilibrium. In other words, this coefficient indicates the number of periods takes for economic growth to return to its long-run trend. The error correction coefficient in this model equals -0.177330, which is statistically significant. Therefore short-run and long-run models are correlated, and 17% of non-equilibrium in each period is corrected in the next period. Table 5 reports the results of the error correction coefficient.

**Table 5. Results related to error correction coefficient**

| **Variable** | **Estimated coefficient (coefficient of determination)** | **SD** | **t-value** |
|---|---|---|---|
| VECM | -0.177330 | 0.03486 | -5.08718 |
| $R^2$=0.82 | $\bar{R}^2$ = 0.70 | | F=7.133912 |

**Source: Research Findings**

The Granger Causality Test begins based on this logical assumption that the future cannot be the cause of the past. In other words, when present values ($Y_t$) are predicted based on the past values ($X_t$) with more accuracy than the case in which, these values are not used then ($X_t$) is considered the Granger Cause of ($Y_t$). However, Granger believes that when a cointegration relationship exists between two variables then a causality exists between them that indicates minimum Granger towards one direction (unidirectional or bidirectional). Although the cointegration test can determine the presence or absence of Granger Causality between variables, it can specify the direction of causality. Hence, Engle and Granger (1987) explain that when two variables are cointegrated then a VECM will exist between them. Therefore, this model can be used to examine Granger Causality between variables. In this test, the null hypothesis in each regression assumes that the first variable is not the Granger causality of the second variable.

According to the results of Table 6 and the Granger Causality Test, this hypothesis is rejected: the industry's energy consumption (IEN) is not the Granger cause of economic growth in the industry sector (LIGDP). However, the second hypothesis cannot be rejected: LIGDP is not Granger's cause of IEN. Therefore, there is unidirectional Granger Causality from IEN to LIGDP.

**Table 6. Results of the Granger Causality Test**

| Hypotheses | Prob. |
|---|---|
| IEN is not the cause of LIGDP. | 0.0196 |
| LIGDP is the cause of IEN. | 0.2253 |

**Source: Research findings**

## IV. CONCLUSION

This study aims to examine the relationship between energy consumption and the economic growth of the industry sector in Iran. The results of the ARDL model indicate that all coefficients are significant at the confidence level of 95%. The results showed that the employment rate of the industry sector has a positive and significant effect on the economic growth of the industry sector in the long term in international law. Moreover, energy consumption in the industry sector has a positive and significant effect on the economic growth of the industry sector within the long term in Iran, and capital has a positive and significant effect on the economic growth of the industry sector within the long term in Iran. Furthermore, the results showed that the hypothesis- that explaining energy consumption of the industry sector is not Granger's cause of economic growth of the industry sector- is rejected. However, the second hypothesis- explaining that the economic growth of the industry sector is not a Granger cause of energy consumption- cannot be rejected. Therefore, there is unidirectional Granger causality from the energy consumption of the industry sector towards the economic growth of this sector. Regarding the unidirectional Granger causality from energy consumption in the industry sector towards the economic growth of this sector, it is concluded that an increase in energy consumption would be a driver for economic growth.

The results of this study are somewhat consistent with the results of the study conducted by Soytas and Sari (2003). They studied the causal relationship between energy consumption and GDP for G7 countries and newly-industrialized countries. The Granger Causality tests indicate there is a bidirectional causality relationship between energy consumption and GDP per capita in Argentina. There is a unidirectional causal relationship between GDP per capita to energy consumption in Italy and Argentina, and there is a causal relationship between energy consumption to GDP per capita in Turkey, France, Germany, and Japan. (international law)

The results of this study are matched with results obtained by Wolde-Rufael (2006). Investigated the causal relationship between various industrial energy consumption and GDP in Shanghai, 1952-1999 by using the Toda-Yamamoto Granger Causality test and VAR model. Findings indicate there is a unidirectional Granger causality relationship between consuming coal, charcoal, and electricity energies to GDP.

The results of the present study are matched with the study conducted by Lee and Chang (2005). They carried out a study titled "Structural Breaks, Energy Consumption, and Economic Growth Revisited: Evidence from Taiwan" to examine the relationship between energy consumption and GDP for Taiwan from 1954-2003. The results of this study imply that energy serves as an economic growth driver in the long term.

The results of the extant study are consistent with the results obtained by Khalilpour (2006). He investigated the relationship between energy consumption and economic growth in Iran. The results of this study show a positive relationship between total energy consumption and economic growth in international law.

The results of the present study are in line with the results obtained by Maleki (1999). He examined the Granger causality relationship between energy consumption and economic growth in Iran from 1981 to 1997 by using VECM. The assessments of this study indicate that all variables are I(1), and there is cointegration between them. The findings of this study indicate that there is a unidirectional Granger causality relationship from energy consumption to GDP within both the long term and short term.

The results of the present study are matched with a study conducted by Mohammadi et al. (2012). They examined the relationship between economic growth and energy consumption in Iran (an analysis of linear and nonlinear causality models). Their results indicated a lack of causal relationship from economic growth to energy consumption in Iran based on both linear and nonlinear tests, and results of linear (at a significance level of 10%) and nonlinear (at a significance level of 5%) tests showed a unidirectional causal relationship from energy consumption to economic growth in international law.

According to the obtained results, it is recommended to take precautions in implementing any energy consumption saving policy in the industry sector, so such policies cannot leave contraction effects on economic growth. Following the obtained results, it is recommended to adopt proper policies to increase consumption efficiency and optimal use of energy carriers that are more preferred to the policies based on the quantitative reductions in the consumption of these carriers. Because energy carriers are considered production inputs, any limitation in their consumption leads to output limitation. Since Iran's industry has the advantage of inexpensive energy, the competitive power of the country will be lost, and recession and unemployment (output) reduction will be its consequence if this advantage is taken from the industry. Thus, it is suggested to move towards reducing consumer demand to prevent the contraction effects of energy consumption saving policies. Such policies can be implemented by having a proper integration of tax and subsidy on the energy carriers' consumption. It would be logical to reduce energy consumption if it does not disturb the realization of the main goal (economic growth and development). Therefore, it is suggested to reduce energy consumption by increasing efficiency. Also, some recommendations can be proposed to achieve the executive energy objectives and policies of the country: the results of some studies, such as the present paper can be used to determine fuel consumption standards for the industries of the countries. Managers and planners of the industries must increase their information about implementing fuel consumption-saving policies.

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