WALIA journal 31(S6): 76-82, 2015
Available online at www.Waliaj.com
ISSN 1026-3861

Dynamic effect of energy consumption on economic growth case study: Iran's industrial sector

Morteza Raei Dehaghi [1, *], Seyed Mohammad Mirhashemi [2]

[1]*Department of Industrial Management, Mobarakeh Branch, Islamic Azad University, Mobarakeh, Isfahan, Iran*
[2]*PhD Student of Economic Science, University of Shiraz, Shiraz, Iran*

Abstract: The aim of this study was to investigate the dynamics effect of energy consumption on economic growth in industrial sector for the period 1980 to 2013 in Iran. Annual data related to energy consumption and value added in the industry sector as well as Augmented Dickey–Fuller test, Johansen Juselius Cointegration test, Vector error correction model and Impulse Response Function were used. The results of the study revealed a positive relationship between energy consumption and value-added of the industry sector. Thus, among the hypotheses on the relationship between energy consumption and economic growth, the growth hypothesis was confirmed.

Key words: *Energy consumption; Economic growth; Industrial sector; Vector error correction model; Impulse response function*

1. Introduction

Economic growth is a process wherein the GDP growth constitutes its major axis. Development planning is targeted to equip financial possibilities and resources towards more production of goods and services, but trying for higher and better production should be accompanied by more extensive use of all resources including human resources, physical capital and natural resources aside from the modifications that are created in organization of production factors. In other words, when the economic growth rate is enhanced tangibly, an increasing pressure is exerted over the resources. In this regard, demand for specialized human force, the need for capital and capital equipment and consumption of raw materials, thus leading the energy to increase. If it is not possible to exploit each one of the above-mentioned resources along with production growth, production will face difficulty. Thus, the relationship between economic growth and consumption of energy carriers such as oil products, natural gas and electricity, as major production factors, has attracted the attention of many economic analysts (Amadeh et al., 2010).

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 (Fetres et al., 2013). 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 a 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 (Sadeghi et al., 2015). 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. But 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 (Bozoklu and Yilanci; 2013). 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 dynamic effect of energy consumption on economic growth of Iran's industrial sector. The present study is organized in six sections. Section 2 addresses theoretical principles and section 3 presents literature review. Sections 4 and 5 present research methodology and the research model. Section 6 provides the results of model estimation and findings and the last section contains discussion and conclusion of the study as well as some suggestions.

* Corresponding Author.

2. Theoretical principles

Neoclassic economists like Berndt and Wood (1975) believe that energy is the factor of production in total production function. They suggested a production function as follows:

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

It means that energy and capital are combined and create production factor G and that the product is obtained after it is combined with labor force. Therefore, energy has a weak separable relationship with labor force (Fetres et al., 2013). Following ecologist economist, including Ayres and Nair (1984) and Stern (1993), pointed out that energy is the only and the most important growth factor; hence, product goods in economy even without the trained and non-specialist manpower are obtained by spending huge values of energy. Labor forces and capital are the intermediary factors that require energy in order to be utilized. Likewise, following neoclassic economists, Stern declared that energy is effective on economic growth indirectly through its effect on labor force and capital.

In the framework of the neoclassic school, Stern and Cleveland (2004) have mentioned the relationship between energy consumption and economic activities in the form of a production function:

$(Q_1, \dots, Q_m) = f(A, X_1, \dots, X_n, E_1, \dots, E_p)$

Where Q_i is manufacturing of different products and services; X_i is various manufacturing inputs such as capital, labor force, etc; E_i is different inputs of energy like oil, coal, etc. Also in this relation, A is technological status or productivity index of total factors. In the above function, the relationship between energy and total production is affected by factors such as replacement between energy and other inputs, technological changes, changing the combination of energy factors and the manufactured product. Though energy factors are inserted in the model in new growth theories, their importance is not similar in different models.

In order to explain the relationship between energy consumption and production in macro-economic literature, assuming that labor force is the changeable input and other inputs are fixed in determining total supply, then the increase of energy price will lead to demand reduction for energy, and thus, labor force productivity is decreased. By decreasing labor force productivity, the demand curve for labor force is transferred to the left side and employment is reduced. When employment is reduced, total supply curve is transferred to the left side. In addition, energy price shock can enhance general level of prices increasing production expenses and thus decreases real national product (Armen and Zare, 2006; Sadeghi et al., 2015).

Generally speaking, it can be stated that there are four hypotheses regarding the relationship between energy consumption and economic growth. The first hypothesis, known as growth theory, indicates that energy is one of the valuable production factors, and capital stock in the process of production and increased energy consumption can be resulted in increased production level and economic growth. The second hypothesis is related to energy saving indicating the policies of energy saving towards decrease energy consumption that give rise to the increase economic growth. The third hypothesis is neutrality hypothesis and illustrates that energy consumption has an insignificant effect on production. This hypothesis is confirmed where there is no relationship between energy consumption and gross domestic product (GDP). The fourth hypothesis, referred to as a feedback hypothesis, indicates that there is a mutual relationship between energy consumption and economic growth (Sadeghi et al., 2015). Each of these hypotheses has been tested in different studies and the results have been different in various countries and different studies.

3. Literature review

In this section, a number of studies conducted in Iran and other countries are mentioned.

Armen and Zare (2006) investigated Granger causality between energy consumption and economic growth in Iran during the time period 1968-2003. They employed autoregressive distributive lag (ARDL) approach, Toda and Yamamoto method, and Granger causality test. The results disclosed that there is a one-way Granger causality relation between total energy consumption of oil products and electricity consumption and a one-way Granger causality relation between economic growth and consumption of natural gas and solid fuels.

Behbudi et al. (2010) 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.

Fetres et al. (2013) 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 are more than that of renewable energy consumption on economic growth.

Nikoueghbal et al. (2013) 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. Also, 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.

Sadeghi et al. (2015) explored the relationship between economic growth and energy consumption in MENA countries, using the gathered data from Middle East countries and North Africa during the time period 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.

Dergiades et al. (2013) explored linear and non-linear causal relationship between energy consumption and performance of the economy in Greece using time-series data in time period 1960-2008. They used vector auto regression 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.

Smiech and Papiez (2014) explored the causal relationship between energy consumption and economic growth considering energy policies in the European Union member states. They used the data of the time period 1993-2011 and Bootstrap panel causality. The results of causal relationship between energy consumption and economic growth were obtained different 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.

Lin et al. (2014) 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.

Omri and Kahouli (2014) investigated causal relationship between energy consumption, foreign direct investment and economic growth by means of dynamic simultaneous equation models. Data of 65 countries during the time period 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. They also concluded that there is a one-way Granger causality relation between foreign direct investment inflow and economic growth as well as between foreign direct investment and economic growth in moderate-income countries. Moreover, according to the results, there is a mutual Granger causality relation between economic growth and foreign direct investment and a one-way relation between economic growth and energy consumption and also between energy consumption and foreign direct investment in low-income countries.

Aside from the mentioned studies, other research studies have been carried out among which Shakibaei and Ahmadlu (2012), Fetres et al (2012), Mehrara and Zarei (2012), Ale Emran et al (2014), Heidari et al (2015) and Yildrim et al (2014) can be mentioned that each one has explored the relationship between energy consumption and economic growth via data of different countries and different methods.

4. Methodology

Vector auto regression 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 auto regression 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 was used in this study.

4.1. Vector error correction model (VECM)

A Vector autoregressive model (VAR) in matrix form can be shown as below:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + U_t \ , \quad U_t \sim (0, \sigma^2)$$

In this relation, Y_t and its lags are vectors k × 1 related to model variables. A_i Per $i = 1, \dots, p$ is k × k matrices of model coefficients and U_t is vector k × k related to error terms of the model. Now in order to link short run behavior Y_t to its long run equilibrium values, the below relation can be stated in the form of vector error correction model as below:

$$\Delta Y_t = B_1 \Delta Y_{t-1} + B_2 \Delta Y_{t-2} + \cdots + B_{p-1} \Delta Y_{t-p-1} + \Pi Y_{t-p} + U_t$$

Matrix Π contains information related to long run equilibrium relations. Indeed, it is $\Pi = \alpha\beta'$ that α shows disequilibrium adjustment coefficients and adjustment speed towards long run equilibrium and β is the matrix for coefficients of long run equilibrium relationships.

4.1.1. Johansen-Juselius method

There may be more than one long run convergent vector in multi-variable analysis of time series. Thus, methods such as Angel-Granger cannot determine these vectors without any presupposition on behalf of the analyst. Johansen and Juselius solved the deficiencies of Angel-Granger method by formulating a method for vector convergence.

4.2. Impulse response function

Depicting impulse response functions is a practical way to observe behaviors of series y_t and z_t in response to different shocks. Indeed, it may be possible to know all parameters of the primary model and track temporal path of the effects of shocks ε_{yt} and ε_{zt} but there exist no such methodology for the researcher, because VAR model is an estimation less than the identification limit. Therefore, econometrics specialists should impose an additional restriction on two-variable VAR system to be able to identify impulse response functions. A possible restriction for identification is Kowalski decomposition where y_t does not have a simultaneous effect on z_t. Although Koleski decomposition constrains the system in a way that shock ε_{yt} does not have any direct effect on z_t but there is an indirect effect where values with lag y_t affect simultaneous values of z_t.

4.3 Research model and variables

It is tried in this study to estimate the model, below, in the framework of vector auto regression model:

$$Log(Y)_t = C_1 + \sum_{i=1}^{K} \alpha_i Log(Y)_{t-i} + \sum_{i=1}^{K} \beta_i Log(EC)_{t-i} + v_{1t}$$

$$Log(EC)_t = C_2 + \sum_{i=1}^{K} \alpha_i Log(Y)_{t-i} + \sum_{i=1}^{k} \beta_i Log(EC)_{t-i} + v_{2t}$$

In these relations, Y shows value-added of the industry sector in terms of U.S. dollar with fixed price and EC is energy consumption in the industry sector in terms of kilotons of crude oil equivalent. Data of the time period, 1980-2013, were used for model estimation and the intended data were obtained from the published information of the World Bank. Data analysis was carried out by means of Eviews 6 software.

5. Results and findings

5.1. Unit root test variables

Stationary of variables was examined using Augmented Dickey–Fuller test. Table 1 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, I (1).

Table 1: 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%.
Source: research findings

5.2. 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 2. Given the results of Table 2, 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).

5.3. 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 3 and 4 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 2: 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 12.517	21.170 4.255	r=1 r=2	r=0 r<=1
λ_{trace}	0.056 0.704	25.872 12.517	25.425 4.255	r=1 r=2	r=0 r<=1

Critical values are at the confidence level 99%.
Source: research findings

Table 3: 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

Source: research findings

Table 4: Error Correction Equation for the Variable LEC

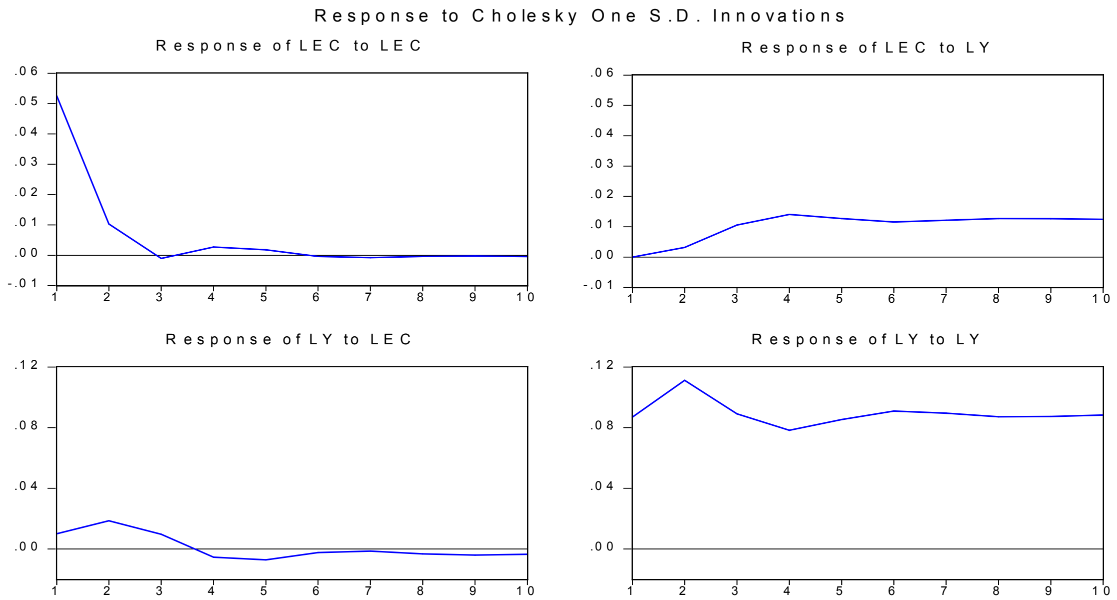
Variables	Coefficients	Probability level
Intercept	0.072	0.017
DLY (-1)	-0.085	0.105
DLY (-2)	-0.017	0.102
DLEC(-1)	-0.046	0.133
DLEC(-2)	-0.036	0.128
CM(-1)	-0.357	0.039

Source: research findings

Coefficient ecm in Table 3 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 ecm in Table 4 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.

5.4. Impulse response

One of the uses of VAR model employed by Simes et al 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. Also, model shows response of the value-added variable in the industry sector to one-standard-deviation shock in energy consumption. So, one-standard-deviation shock in energy consumption increases value-added in the industry sector and then its effect inclines towards zero after 4 periods.



Source: research findings
Fig. 1: Response of variables to one-standard-deviation shock in LEC and LY

6. Discussion and conclusion

With regard to the relationship between energy consumption and economic growth, there are four hypotheses. The first hypothesis, known as growth theory, states that energy as one of the valuable production factors is considered in the production process, altogether with labor force and capital inventory and increased energy consumption can increase production and economic growth. The second hypothesis is related to energy saving indicating that energy saving policies will decrease energy consumption that will enhance economic growth. The third hypothesis is neutrality hypothesis and illustrates that energy consumption has an insignificant effect on production. This hypothesis is confirmed when there is no relationship between energy consumption and gross domestic product. Hypothesis four, referred to as mutual relation hypothesis or feedback hypothesis indicates that there is a mutual relationship between energy consumption and economic growth (Sadeghi et al., 2015).

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 the time period 1980-2013. 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. Also, the 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 Behbudi et al (2010), Fetres et al (2012), some results of Nikoueghbal et al (2013), Smiech and Papeiz (2014), Lin et al (2014) and Dergiads et al (2013) and are different from the results obtained by Bozoklu and Yilanci (2013), Omri and Kahouli (2014) and Sadeghi et al (2015).

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 because 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.

Therefore, given the research results, it is suggested that if macro purpose of the country's policy is to accelerate the development and growth process of the industry sector, any restrictive policy with regards to energy consumption leading to the reduction of demand and productivity of factors will prevent the decline in the production process. What is certain is that the industry has already two advantages of cheap energy and allocative currency. In the event that these two advantages are omitted in the industry, its competitive power will be lost and if its activity continues, increased price of industrial products will be at the level and that the internal demand structure cannot attract these products. As a result, recession and unemployment (production decrease) will be its natural consequences.

References

Ale Emran R., Panahi H. and Kabiri Z.; 2014. Exploring the causal relationship among economic growth, CO_2 emission, energy consumption and employment ratio in Iran. *Geography and Planning*, 45, pp. 1-26.

Amadeh H., Ghazi M. and Abasifar Z.; 2010. Exploring the relationship among energy consumption, economic growth and employment in different sectors of economy. *J. of Eco. Res.*, 86, pp. 1-38.

Armen S.A. and Zare R.; 2010. Energy consumption in different sectors and its relationship with economic growth in Iran: Analysis of causality based on Tuda and Yamamoto method. *Quart. Energy Eco. Review*, 21, pp. 67-92.

Behbudi D., Asgharpour H. and Ghazvinian M.H.; 2010. Structural failure, energy consumption and economic growth (1968-2006). *J. of Eco. Res.,* 3, pp. 53-84.

Bozoklu S. and Yilanci V.; 2013. Energy consumption and economic growth for selected OECD countries: Further evidence from the Granger causality test in the frequency domain. Energy Policy, 63, pp. 877–881.

Dergiades T., Martinopoulos G. and Tsoulfidis L.; 2013. Energy consumption and economic growth: Parametric and non-parametric causality testing for the case of Greece. Energy Eco., 36, pp. 686-697.

Fetres M.H., Aghazade A. and Jebraeili S.; 2012. Effect of economic growth on renewable energy consumption: Comparative analysis of the selected member and non-member countries in the Organization for Economic Cooperation and

Development (including Iran). *J. of Eco. Res. and Policies*, 60, pp. 81-98.

Fetres M.H., Aghazade A. and Jebraeili S.; 2013. Exploring the effect of renewable and nonrenewable energy consumption on economic growth of the selected developing countries (including Iran) in 1980-2009. *Quart. Energy Eco. Review*, 32, pp. 51-72.

Heidari H., TuranKatircioglu S. and Saeidpour L.; 2015. Economic growth, CO2 emissions, and energy consumption in the five ASEAN countries. Electrical Power and Energy Systems, 64, pp. 785–791.

Hu H., Zhang X. and Lin L.L.; 2014. The interactions between China's economic growth, energy production and consumption and the related air emissions during 2000–2011. Ecological Indicators, 46, pp. 38–51.

Lin B., Presley K. and Wesseh J.R.; 2014. Energy consumption and economic growth in South Africa reexamined: A nonparametric testing approach. Renewable and Sustainable Energy Reviews, 40, pp. 840–850.

Mehrara M. and Zarei M.; 2012. Non-linear effects of energy consumption on economic growth based on threshold limit. *J. of Eco. Growth and Dev.*, 5, pp. 11-43.

Nikueghbal A., Akhtari A., Amini Asfidojani M. and Atar Kashani M.; 2013. Economic growth, energy consumption growth, and CO_2 emission growth: Exploiting the causality relation via dynamic panel data approach (DPD). *Quart. Energy Eco. Review*, 33, pp.169-197.

Omri A., and Kahouli B.; 2014. Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models. Energy Policy, article in press.

Sadeghi S.K., Ghamari N. and Feshari M.; 2015. Exploring causal relationship between energy consumption and GDP in MENA countries (generalized method of moments in panel data). Macroeconomics: *Iranian Eco. J.,* 17, pp. 121-140.

Shakibaee A. and Ahmadlu M.; 2012. Exploring the relationship between energy consumption and growth of economic sub-sectors in Iran (1968-2008): Vector error correction model. *Quart. Energy Eco. Review*, 30, pp. 181-203.

Smiech S. and Papiez M.; 2014. Energy consumption and economic growth in the light of meeting the targets of energy policy in the EU: The bootstrap panel Granger causality approach. Energy Policy, 71, pp. 118–129.

Stern D.I. and Cleveland C.J.; 2004. Energy and economic growth. Working papers in Economics. Rensselaer Polytechnic Institute, Boston University.

Stern D.I.; 1993. Energy use and economic growth in the USA: A multivariate approach. *Energy Eco.,* 15, pp. 137-150.

Yildrim E., Sukruoglu D. and Aslan A.; 2014. Energy consumption and economic growth in the next 11 countries: The bootstrapped autoregressive metric causality approach. Energy Eco., 44, pp. 14–21.