Investigating the Effect of Using Oil, Natural Gas and Coal on Economic Growth of Iran

Naser Ali Yadolahzade Tabari[1]*, **Fateme Nazari**[2],
Maryam Shafiee Kakhki[3]

Abstract

The purpose of this study is to investigate the role of oil, natural gas and coal consumption in Iran's economic growth during the periods from 1980 to 2012. The stationary analysis is performed by using ADF and Phillips-Perron unit root test and Auto-Regressive Distributed Lag (ARDL) approach was used to test for co-integration between the variables. The findings show that the variables are cointegrated; it means there is a long-run equilibrium relationship between the consumption of energy and economic growth. Accordingly the consumption of natural gas and coal was concluded to have positive and significant effect on economic growth, while the consumption of petroleum shows no significant effect on economic growth.

Keywords: ARDL method, coal, gas, oil.
JEL Classification: O4, C22

1. Introduction

Iran's energy consumption has increased from 1961 due to structural economic changes, industrial development and growing urbanization in this country. After Islamic revolution, the economic and political evolutions led to decrease in both energy consumption and production. With the onset of war and the damage to supply lines, energy consumption was rationed. The rapid growth of energy consumption was seen in 1989, after releasing oil production (Armen and Zare, 2005).On the other hand, natural gas is now used in areas such as injection into oil fields, compressed natural gas and petrochemical industry where it has a significant place in manufacturing sector and domestic consumption of Iran's economy. Coal is the most

---

1. Department of Economic, Babol Branch, Islamic Azad university, Babol, Iran (corresponding author: nasertabari@yahoo.com)
2. Department of Economic, Babol Branch, Islamic Azad university, Babol, Iran (Email:fatemehnazari57@yahoo.com)
3. Department of Economic, Babol Branch, Islamic Azad university, Babol, Iran (Email:mshafieek@gmail.com)

important produced source of energy taking the second place in the world as an energy carrier (Ashgharpour et al., 2008). It is the largest source of energy for the generation of electricity worldwide, as well as one of the largest worldwide anthropogenic sources of carbon dioxide releases. Converting the ubiquitous rock into an economical, clear, and arguably clean form of jet fuel, the coal would be able to replace imported aviation fuel in the near future and become a strategic commodity. Because of the abundance and distribution of coal[1] in the world, it can be considered as a suitable substitute for oil and gas, providing countries protection against energy shocks (Behnameh, 2011).Coal provides the largest fuel supply for power plants around the world and it expects to continue to maintain a significant share of the electricity generation by 2030.The use of coal is increasing every year, today the countries share of the world's coal consumption is 30.3% and it is expected to be 32% by 2030.Oil will maintain the largest share of primary energy supply by 2035,and other energies including the coal, gas, nuclear and renewable energies will have respectively second, third, fourth and fifth places (Zarghami, 2012). There are some weaknesses related to the coal industry including:

- The lack of effective and economic utilization of coal resources.
- The failure to develop the infrastructure to increase the production and add diversity to energy supply portfolio.
- The obligation to determine the coal price with no connection to the market mechanism.
- The high cost of coal due to the lack of modern machinery to be used in the mining and exploration divisions.
- The limitations derived from the political circumstances and international sanctions imposed on coal sector development and related activities.
- The failure to attract foreign investment to develop innovative and environmentally friendly technologies
- The failure to increased exploration and development of mining and energy resources, processing industries, energy and power plants.

2. Theoretical Framework

Prior to the presentation of growth theory by Romer, there were other theories including Solow growth theory in which technology has mostly been seen as an exogenous factor. The key assumption of the neoclassical growth model is that capital is subject to diminishing

---

1. Coal (by liquefaction technology) is one of the backstop resources that could limit escalation of oil prices and mitigate the effects of transportation energy shortage that will occur under peak oil. This is contingent on liquefaction production capacity becoming large enough to satiate the very large and growing demand for petroleum.

returns in a closed economy[1]. Diminishing returns to labor and capital, constant return to scale, competitive market and fixed rate savings are main assumptions in Solow growth theory. But what is important in this theory is the relationship between the long-term per capita growth rate and technological progress rate. Accordingly, the long-term per capita growth rate is pegged by the rate of exogenous technological progress. This theory attempts to explain long-run economic growth by looking at capital accumulation, labor or population growth, and increases in productivity, commonly referred to as technological progress.

Romer in his first paper on endogenous growth in 1986 presented a variant on Arrow's model which is known as learning by investment. He assumes creation of knowledge as a side product of investment. Crucial importance, in his assumptions, is usually given to the increasing returns to scale due to positive external effects, the importance of human capital (knowledge, skills and individual training), the production of new technologies for long-run growth, private investment in research and development as the main source of technological development and taking knowledge and technology as a non-rival goods. He takes knowledge as an input in the production function of the following form

$$Y = A(R) \ F(R_i, K_i, L_i)$$

where Y is aggregate output; A denotes the public stock of knowledge from research and development, R_i is the stock of results from the stock of expenditure on research and development by firm i, K_i and L_i are capital stock and labor stock of firm i respectively. In fact R_i denotes the technological progress. From the forgoing, we can derive the aggregate production function of the endogenous theory as follow:

$$Y = F \ (A, K, L)$$

where Y denotes the aggregate real output, K denotes the stock of capital, L denotes the stock of labor, A denotes the technology (or technological advancement). It is worthy of note that technology is seen as an endogenous factor which could be related to energy. Technology, in a period of time, hinges on the available energy. The reason why is that technology will be useless if there is no energy supply. According to the law of thermodynamics, nothing happens in the world without energy conversion and entropy

---

1. Given a fixed stock of labor, the impact on output of the last unit of capital accumulated will always be less than the one before. Assuming for simplicity no technological progress or labor force growth, diminishing returns implies that at some point the amount of new capital produced is only just enough to make up for the amount of existing capital lost due to depreciation. Assuming non-zero rates of labor growth complicates matters somewhat, but the basic logic still applies– in the short-run the rate of growth slows as diminishing returns take effect and the economy converges to a constant "steady-state" rate of growth (that is, no economic growth per-capita).

production. In other words, high consumption of energy and material is needed to produce and maintain capital and thus it is evident the importance of energy in the production process of goods. Theories can be tested in the analysis of the relationship between economic growth and energy carrier consumption using two approaches namely supply side approach and demand side approach that can be studied based on growth theory and on the price effects of energy carriers' consumption on economic growth respectively. Pindyck (1979) believes that the effect of energy prices on economic growth hinges on the role of energy in the production structure. According to his opinion, the increase in energy prices results in decrease in domestic production for those industries where energy is used as an intermediate input. The reason why is due to decrease in energy consumption followed by the increase in energy prices. He believes if we consider labor and capital as a substitute for energy, the increase in energy prices will result in increase in the use of both capital and labor. The increase in production costs, due to increase in energy prices, causes to change in the allocation of production factors as well. Total energy, in the production function, is a production factor having poor separable connection with labor as Douglas (1991) quotes from the citation of Berndt and Wood (1975). The energy, in production function proposed by them, combines with capital and the resulting composite is then combined with labor. The composite then combines with materials in the upper nest to produce output. Therefore, energy consumption affects the marginal product of capital without affecting the marginal product of labor. Some other economists, on the other hand, believe that the amount of energy is constant in the universe. It doesn't disappear. It is compensable and convertible to matter. The production of economic commodities, in biophysical model of growth, requires tremendous amounts of energy (Amadeh et al., 2009). Stern (1993) believes that capital and labor are intermediate factors that require energy and materials for their production.

3. Literature Review

Behnameh (2011) investigated the causal relationship between coal consumption and economic growth in Iran. The results showed that there was no long run relationship between these two variables. There was also no short run causal relationship between coal consumption and economic growth. On the other words, there was neither a long-run nor a short-run relationship between these two variables namely; the increase in coal consumption had no effect on economic growth. Thereby, saving in coal consumption does not lead to decrease in economic growth based on neutral hypothesis.

Li and Leung (2012) used the panel model and the error correction model to examine the relationship between coal consumption and real GDP in China. The results indicated that there is a bilateral causal relationship between these two variables.

Lim and Yoo (2012) used the Granger causality and the error correction

model to examine the relationship between natural gas and real GDP in United States. The results indicated that there is a bilateral causal relationship between these two variables.

Shahbaz et al. (2013) used the ARDL method in which three variables including capital, labor force and export were added to the model. They concluded that there is a long run relationship between these variables so, the natural gas consumption, capital, export and labor force have a positive effect on economic growth.

Bashiri et al. (2014) used the Granger causality and the co-integration tests to examine the relationship between the consumption of crude oil and economic growth in Latin America. The results led them to the conclusion that there was no causal relationship between the consumption of crude oil and economic growth in the Caribbean and South America. However, there was a one-way causal relationship between the consumption of crude oil and economic growth in the Central America.

4. Model Specification

The following model is specified to analyze the empirical results and study the relationship between economic growth and its effective factors including oil consumption, natural gas consumption and coal consumption, according to the previous studies, particularly those by Bildirici and Bakirtas (2013).

$$GDP_t = f\left(OEC_t, NGC_t, CEC_t\right) \tag{1}$$

where the (GDP), as a symbol of economic growth and a dependent variable, is the gross domestic product at 2005 constant price. The (OEC) as an independent variable, is the oil energy consumption (millions tons), (NGC) as an independent variable, is a natural gas consumption (billion cubic metric), (CEC) as an independent variable, is a coal energy consumption (millions tons). The related data used in this study are annual observations covering the thirty-three year period from 1980-2012 taken from BP Statistical Review of World Energy and World Bank.

Note that both the dependent and the independent variables are natural logarithms:

$$LnGDP_t = \alpha_0 + \alpha_{OEC} LnOEC_t + \alpha_{NGC} LnNGC_t + \alpha_{CEC} LnCEC_t + \mu_i \tag{2}$$

5. Econometric Methodology
5.1. Model Estimation Method

The conventional method has recently been used to study the long-run co-integration between variables is the Autoregressive Distributed Lag method proposed by Pesaran et al. (2001). An ARDL model is a dynamic model in which the effect of a regressor like x on y occurs over time rather than all at once. This approach has two phases to estimate the long run relationship. In the first phase, the long run relationship between variables in equation is to

study and in the second phase, the long run and short run coefficients are to estimate (Shahbaz, 2007):

The ARDL model is given by the following equations:

$$ARDL\left(p,q_1,q_2,...q_k\right)$$

$$\varnothing(l,p)y_t = \sum_{i=1}^{k}\beta_i\left(l,q_i\right)x_{it} + S'\omega_t + u_t \tag{3}$$

$$\varnothing(l,p) = 1 - \varnothing_2 l^2 - ... - \varnothing_p l^p$$

where

$$i = 1, 2, ..., k$$

$$\beta_i\left(l,q_i\right) = 1 - \beta_{i1}l - \beta_{i2}l^2 - ... - \beta_{iq_i}l^{q_i}$$

Another method has been proposed to study the long run relationship between variables regardless of the order of I(0) and I(1) named Bounds Testing Approach. The Wald or F-test is used in this method. The Wald test is a parametric statistical test. Whenever a relationship within or between data items can be expressed as a statistical model with parameters to be estimated from a sample, the Wald test can be used to test the true value of the parameter based on the sample estimate.

$$\tag{4}$$

$$\Delta Y_t = C + \delta Y_{t-1} + \sum_{m=1}^{n}\delta_m X_{m,t-1} + \sum_{j=1}^{p}\omega_j \Delta Y_{t-j} + \sum_{m=1}^{n}\sum_{i=0}^{q}\theta_{m,i}\Delta X_{m,t-1} + \varepsilon_t$$

There are two hypotheses in this test:

First, there is no long run relationship between variables.

Second, there is a long run relationship between variables.

$$H_0 : \delta_1 = \delta_2 = ... = \delta_m = 0$$

$$H_1 : \delta_1 \neq \delta_2 \neq ... = \delta_m \neq 0$$

The error correction is the last stage of estimation:

$$\Delta Y_t = \varnothing + \sum_{j=1}^{p}\varnothing_j \Delta Y_{t-j} + \sum_{m=1}^{n}\sum_{i=0}^{q}\beta_{m,i}\Delta X_{m,t-i} + \lambda ECM_{t-1} + u_t \tag{5}$$

6. Estimating the Model

6.1. Stationary Testing

The stationary testing is done before the co-integration testing in order to sure that none of the variables are of order I(2), as it is required to avoid spurious results or erroneous interpretation. The Phillips-Perron (PP) Unit Root Test is used in time series analysis to test the null hypothesis that a time series is integrated of order 1. It builds on the Dickey–Fuller test of the null hypothesis. The Dickey–Fuller test involves fitting the regression model. The stationary variables have been shown on Table 1 based on Phillips-Perron (PP) Unit Root Test and Dickey–Fuller test. The results derived from both tests show that none of the variables are of order I(2) and economic

growth, oil consumption, natural gas consumption and coal consumption variables become stationary after first differencing.

Table 1. Unit Root Test

unit root test	Differencing	GDP	OEC	NGC	CEC
Dickey – Fuller (intercept and trend)	Level	-0.46 (0.8838)[1]	-2.86 (0.1855)	-3.06 (0.1309)	-1.00 (0.9294)
	First difference	-3.40[***2] (0.0691)	-5.23[*] (0.0010)	-7.01[*] (0.0000)	-6.25[*] (0.0001)
Dickey – Fuller (intercept)	Level	-2.81 (0.2023)	-2.56 (0.1097)	-1.35 (0.5899)	-1.79 (0.3769)
	First difference	-3.10[**] (0.0367)	-4.46[*] (0.0013)	-6.83[*] (0.0000)	-5.41[*] (0.0001)
Phillips-Perron(intercept and trend	Level	-2.04 0.5454	-1.82 0.6704	-3.32[***] 0.0799	-1.06 0.9198
	First difference	-3.67[**] 0.0392	-5.32[*] 0.0008	-16.49[*] 0.0000	-7.98[*] 0.0000
Phillips-Perron (intercept)	Level	-2.28 0.1836	-1.99 0.2866	-1.88 0.3356	0.98 0.7454
	First difference	-3.80[*] 0.0070	-4.99[*] 0.0004	-10.84[*] 0.0000	-6.54[*] 0.0000
Results		I(1)	I(1)	I(1)	I(1)

1. P-values
2. *,**,*** show the significance levels at 1% , 5% and 10% respectively.

6.2. Analysis of Results
Bounds Testing Approach
The first step is to determine the optimal lag length p and also study if there is a need to enter a definite time trend in the model. Considering annual data, the optimal lag length, in this study, was selected to be three, based on Akaike information criterion (AIC) and Schwarz Bayesian Criterion (SBC). It is decided to do a joint significance test (Wald test) in order to examine if there is a long run equilibrium relationship among the variables namely between the oil consumption and economic growth, natural gas consumption and economic growth, coal consumption and economic growth for lagged levels of variables under three scenarios for the definite agents. These three scenarios are as follows:

    III: unrestricted intercept and no trend
    IV: unrestricted intercept and restricted trend
    V: unrestricted intercept and unrestricted trend (Nasrollahi, 2004).

    The F-statistics value in this study was 9.1537[0.0001]which was well above the upper boundary, so it can be said with certainty that the variables in the economic growth function of Iran were co-integrated during the study and there was a long run relationship between them as well.

Table 2. The Critical Values for Three Patterns of Bounds Testing

K=2	%1	%5	%10
FIII	5.15;6.36	3.79;4.85	3.17;4.14
FIV	4.99;5.58	3.88;4.61	3.38;4.02
FV	6.34;7.52	4.87;5.85	4.18;5.06

The dynamic relationship: Diagnostic tests were performed to examine the validity of the estimated dynamic models. It is not rejected as a plausible value and a test of the null hypothesis that there is no serial autocorrelation among the error terms, correctly-specified equation, normally distributed residual terms and the homogeneity of variance.

The long-term relationship: Table 3 shows the results derived from estimating the long-term relationship. The natural gas consumption and coal consumption variables have significant coefficients and are consistent with theoretical expectations. Each variable coefficient shows economic growth's elasticity relative to that variable. The oil consumption coefficient continues to be statistically insignificant and negative. The natural gas consumption, however, has a significant positive effect on economic growth. This means that a one percent increase in natural gas consumption leads to a 0.37 percent increase in economic growth. There is also a significant positive relationship between coal consumption and economic growth. This means that a one percent increase in coal consumption leads to a 0.30 percent increase in economic growth as well.

Table 3. Long-termelasticityamong economic growth and energy consumption

Regressor	Coefficient	Standard deviation	T-statistics	P-Value
LOEC	-0.30277	0.32029	0.094528	0.926
LNGC	0.37392	0.16209	1.8718	0.079
LCEC	0.30340	0.11880	3.1473	0.006

The short-term relationship and speed of adjustment
The ECM coefficient of -0.21 proves the co-integration between variables as there is a significant negative relationship between them. This means that the non-equilibrium model, in each period, is adjusted to 21 percent, getting closed to the long-term equilibrium.

6.3. Stability Testing
The CUSUM (Cumulative Sum) and CUSUMQ (Cumulative Sum of Square) stability tests were used to examine the stability of coefficients. The null hypothesis that the coefficients are stable was accepted, in both tests, at the significance level of 5%. So the results are valid.

7. Conclusion

The energy consumption has a special place in the economic development of a country as an important input in the production. Economic growth is a process by which a country's capacity to provide goods and services increases in such a manner that there will be an increase in real gross domestic product growth. The role of oil, natural gas and coal consumption in economic growth of Iran has been discussed in this study. The natural gas logarithm with a positive coefficient indicates that there is a positive relationship between energy consumption (natural gas consumption) and Iran's economic growth. Our findings are consistent with those of Shahbaz et al. (2013), Bildirici and Bakirtas (2013), Lim and Yoo (2012), Zamani (2007), Asghar pour et al. (2008), Armen and Zare (2005), Najarzadeh and Mohsen (2004). The coal variable with a positive coefficient indicates that there is a direct relationship between energy consumption (coal consumption) and Iran's economic growth. It also can be used as a complement to labor and capital in the production process. This result is in accordance with the growth hypothesis that there is a positive relationship between coal consumption and economic growth. Our findings are consistent with those of Yoo (2006), Apergis and Payne (2009), Cheng and Lai (1997), Li and Leung (2012), Yuan et al. (2008), Lee and Chang (2005).

The results that there is no significant relationship between economic growth and oil consumption can be important for making energy policies so as to determine how to manage the energy intensive technologies and regulate the energy subsidies besides the fact that the increase in oil consumption on one hand leads to increase in the level of pollutants and on the other hand may cause the reduction in foreign exchange earnings from oil exports. It can be deduced from the positive effect of natural gas consumption on economic growth that the policy on the elimination of natural gas subsidies namely the liberalization of energy prices particularly in the case of natural gas, may have adverse effect on economic growth as well as the manufacturing sectors. On the other hand, it seems that trying to develop technologies that come up with a greater emphasis on the use of natural gas and coal (if it is technically feasible), may be a reasonable decision especially in power stations and those energy-intensive industries who consume energy the most. The destructive environmental effects can be reduced by minimizing the oil consumption in the domestic economy in addition to maintaining petroleum reserves and converting them to high value-added products.

References

1. Asgharpour Hossein, Behboodi Davood, Qazvinian Mohammed Hussein (2008). Structural Failure: Natural gas consumption and economic growth in Iran, Economics: Energy Economics Studies. no.19, pp.105-122.
2. Armen Seyed Aziz, Zare Rohollah (2005). "Investigating the Granger

causal relationship between energy consumption and economic growth in Iran during the periods from 1987 to 2003". Journal of Economic Research, no.24 (seventh year) pp. 117-143.

3. Amadeh Hamid, Qazi Morteza, Abassifar Zohreh (2009). "investigating the relationship among energy consumption, economic growth and employment invarious economic sectors of Iran". Economic Researches, no.86, pp. 1-38.

4. Apergis, N., Payne, JE. (2009). The Causal Dynamics between Coal Consumption and Growth: Evidence from Emerging Market Economics, Applied Energy, no.87, pp.1-6.

5. Behnameh, Mehdi (2011). "investigating the long run and short run relationship between coal consumption and economic growth in Iran".Economic Development Strategy, no.25, pp. 248-265.

6. Bashiri Behmiri, N., Pires Manso, JR. (2014). The linkage between crude oil consumption and economic growth in Latin America: The panel framework investigations for multiple regions Original. Research Article, Energy, In Press, Corrected Proof.

7. Berndt, E.R., Wood D.O. (1975). Technology, Prices and the Derived Demand for Energy. Review of Economics and Statistics, no.57, pp. 259-268.

8. Bildirici, M.E., Bakirtas, T. (2013). The relationship among oil, natural gas and coal consumption and economic growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) countries.

9. Cheng, B.S, Lai, T.W. (1997). An Investigation of Co-integration and Causality between Energy consumption and Economic Activity in Taiwan, no.19, pp. 435-444.

10. Douglas, R.B. (1991). On the Macroeconomic Effects of Energy Resource and energy, Vol.13, no.2, p. 148.

11. Lim, H.J., Yoo, S.H. (2012). Natural gas consumption and economic growth in Korea: a causality analysis. Energy Sources Part B Econ Plan Policy, no.7, pp. 169-76

12. Li, R., Leung, GCK. (2012). Coal consumption and economic growth in China. Energy Policy, no.40, pp. 438-43.

13. Lee C.C., Chang C.P. (2005). Structural breaks, energy consumption and economic growth revisited: evidence from Taiwan. Energy Economic, no.27, pp.857-72.

14. Najarzadeh Reza, Abbas Mohsen, Azam (2004). "The relationship between energy and economic growth in Iran." Journal of Energy Economics, no.2, (the first year).

15. Nasrollahi, Mohammed (2004). "Iran's total import demand function"A re-evaluation of the "Bounds Testing Approach", journal of economic research, no.66, pp. 91-112

16. Pesaran, M.H., Shin, Y., Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics. no.16, pp. 289-326.

17. Pindyck, R.S. (1979). The Structure of World Energy Demand. MIT Press.
18. Stern, D.I. (1993). Energy and Economic Growth in the U.S.A A Multivariate Approach, Energy Economics. no.15, pp..37-150.
19. ShahbazAkmal, M. (2007). Stock Returns and Inflation: An ARDL conometric Investigation Utilizing Pakistani Data; Pakistan Economic and Social Review, Vol. 45, no.1, pp.89-105.
20. Shahbaz, M., Lean, HH., Farooq A. (2013). Natural gas consumption and economic growth in Pakistan. Review Article, Renewable and Sustainable Energy Reviews, Vol.18, pp. 87-94.
21. Yoo, S. (2006). Causal relationship between coal consumption and economic growth in Korea. Applied Energy,no. 83, pp.1181-9.
22. Yuan, JH., Kang, JG., Zhao, CH., Hu, ZG. (2008). Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels, .EnergyEconomic,no.30, pp.77-94.
23. Zamani, M. (2007). Energy consumption and economic activities in Iran. Energy Economy, no.29, pp..1135-40.
24. Zarghami Sadeq (2012). free sector "The status of coal in Iran" Energy Economic, no 151 and 152, pp. 248-265.