



CAUSALITY BETWEEN OIL CONSUMPTION AND ECONOMIC GROWTH IN IRAN: AN ARDL TESTING APPROACH

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ABSTRACT

Oil is also very important for the Iran's economic growth. This paper studies the causal relationships between oil consumption and economic growth for Iran using cointegration and error correction model from annual data covering the period of 1980-2010. As economic growth and oil consumption variables used in empirical analysis was integrated of order one, employed Granger causality test. The results show that in the short-run, the Granger causality runs from economic growth to energy consumption In Iran. However, in the long run there is not any Granger causality relationship for this country. In other words, if unidirectional causality runs from energy consumption to income, reducing energy consumption could lead to a fall in economic growth.

Key Words: Oil Consumption, Economic Growth, Cointegration.

INTRODUCTION

Oil now constitutes a critical factor in sustaining the well-being the Iran's as well as the nation's economic growth. Production in industries such as manufacturing, transportation, and electricity generation demands a substantial amount of oil. Therefore, oil supply side measures in harmony with economic growth are needed. In addition to supply side measures, demand side management measures are also needed. The oil intensity in Iran is much larger than those in the developing countries. High oil intensity in Iran reflects inefficient oil usage in industries and/or agriculture and indicates that there are high oil-saving potentials. Thus, improving oil consumption efficiency of automobiles and machines and introducing various kinds of tariff reforms aiming to control oil consumption patterns through leveling projected oil demand and saving supply costs of oil can

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induce a high degree of efficiency in the existing facilities without adversely affecting a high level of oil consumption for economic growth.

The direction of causality between energy consumption and economic growth has significant policy implications for countries, enjoying implicit generous subsidies (low domestic prices) for energy. The literature concerning the relationship between energy consumption and economic growth has led to the emergence of two opposite views. One point of view suggests that energy use is a limiting factor to economic growth. The other point of view suggests that energy is neutral to growth. This is known in the literature as the 'neutrality hypothesis' which proposes that the cost of energy is a small proportion of GDP, and so it should not have a significant impact on output growth. It has also been argued that the possible impact of energy use on growth will depend on the structure of the economy and the stage of economic growth of the country concerned. As the economy grows its production structure is likely to shift towards services, which are not energy-intensive activities (Solow, 1978; Cheng, 1995; Asafu-Adjaye, J., 2000).

There are a large number of papers examining the empirical relationships between energy use and economic growth. One on the categories these studies in to four main approaches: One approach is based on a traditional VAR (Sims, 1972) and Granger's causality testing, which assumed that the data are stationary (Erol and Yu, 1987; Abosedra and Baghestani, 1989). The other two approaches are assuming that the variables are non-stationary and consequently, the cointegration technique is the appropriate tool for investigating these relationships (Asafu-Adjaye, J., 2000).

Another approach is, based on the Granger (1988) two stage procedure; in this approach the variable are tested pairs by cointegrating relationships and error correction models to test for Granger causality (Glasure and Lee, 1997).

In the third approach multivariate estimators are based (Johansen, 1990), which facilitated estimations of systems of equation where restrictions on cointegrating relations can be tested and information on short-run adjustment are investigated. The multivariate approach also allows for more than two variables in the cointegration relationship (see, e.g. Masih and Masih, 1998; Asafu-Adjaye, 2000). The last and fourth approach utilizing the Panel-based error correction models, which providing more powerful tests compared to the time series approach. In some of the literature the focuses is on the relationship between energy consumption and economic growth. However, when it comes to whether energy consumption in the result or a prerequisite for, economic growth, one cannot find a clear trends in the literature. Depending on the methodology used, and the country and time period studied, the direction of causality is ambiguous and controversial (Asafu-Adjaye, J., 2000).

In this paper, we intend to examine the relationship between oil consumption and economic growth for Iran, according to Odhiambo. M. N., (2010) article.

The purpose of this paper is, therefore, to investigate the causality between oil consumption and economic growth, and to obtain policy implications from the results. The paper is organized in the following fashion. Section 2, describe the econometric methodology. Section 3 presents data and empirical study. Final section contains the conclusions.

ECONOMETRIC METHODOLOGY

Cointegration – ARDL-Bounds Testing Procedure

In this regard, by applying the model suggested by Odhiambo, 2010 the recently developed Autoregressive Distributed Lag (ARDL)-Bounds testing approach is used to examine the long-run relationship between oil consumption and economic growth. The ARDL modelling approach was originally introduced by Pesaran and Shin (1999) and later extended by Pesaran et al. (2001).

$$\Delta \ln OILCON_t = \beta_0 + \sum_{i=1}^n \beta_{1i} \Delta \ln OILCON_{t-i} + \sum_{i=0}^n \beta_{2i} \Delta \ln Y_{t-i} + \beta_3 \ln OILCON_{t-1} + \beta_4 \ln Y_{t-1} + \mu_t \quad (1)$$

$$\Delta \ln Y_t = \delta_0 + \sum_{i=1}^n \delta_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^n \delta_{2i} \Delta \ln OILCON_{t-i} + \delta_3 \ln Y_{t-1} + \delta_4 \ln OILCON_{t-1} + \mu_t \quad (2)$$

Where: $\ln OILCON$ = log of oil consumption; $\ln y/N$ = the log of real per capita income; μ = white noise error term; Δ = first difference operator.

The bounds testing procedure is based on the joint F-statistic (or Wald statistic) for cointegration analysis. The asymptotic distribution of the F- statistic is non-standard under the null hypothesis of no cointegration between examined variables. Pesaran and Pesaran (1997) and Pesaran et al. (2001) report two sets of critical values for a given significance level. One set of critical values assumes that all variables included in the ARDL model are I(0), while the other is calculated on the assumption that the variables are I(1). If the computed test statistic exceeds the upper critical bounds value, then the H_0 hypothesis is rejected. If the F-statistic falls into the bounds then the cointegration test becomes inconclusive. If the F-statistic is lower than the lower bounds value, then the null hypothesis of no cointegration cannot be rejected (Odhiambo, 2010).

Granger Non-Causality Test

The existence of cointegration relationships indicates that there are long-run relationships among the variables, and thereby Granger causality among them in at least one direction. The ECM was introduced by Sargan (1964), and later popularized by Engle and Granger (1981). It is used for correcting disequilibrium and testing for long and short run causality among cointegrated variables. The ECM used in this paper is specified as follows:

$$\Delta \ln Y_t = \delta_0 + \sum_{i=1}^n \delta_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^n \delta_{2i} \Delta \ln OILCON_{t-i} + ECM_{t-i} + \mu_i \quad (3)$$

$$\ln OILCON_t = \beta_0 + \sum_{i=1}^n \beta_{1i} \Delta \ln OILCON_{t-i} + \sum_{i=0}^n \beta_{2i} \Delta \ln Y_{t-i} + ECM_{t-i} + \mu_i \quad (4)$$

Where ECM_{t-i} = the lagged error-correction term obtained from the long-run equilibrium relationship.

Although the existence of a long-run relationship between OILCON and y/N suggests that there must be Granger-causality in at least one direction, it does not indicate the direction of temporal causality between the variables. The direction of the causality in this case can only be determined by the F-statistic and the lagged error-correction term. It should, however, be noted that even though the error-correction term has been incorporated in all the equations (3) – (4), only equations where the null hypothesis of no cointegration is rejected will be estimated with an error-correction term (Odhiambo, 2010).

In each equation, change in the endogenous variable is caused not only by their lags, but also by the previous period's disequilibrium in level. Given such a specification, the presence of short and long-run causality could be tested (Aktaş, Cengiz and Yılmaz, Veysel., 2008).

ADF Unit Root Test

Nelson and Plosser (1982) argue that almost all macroeconomic time series typically have a unit root. Thus, by taking first differences the null hypothesis of nonstationarity is rejected for most of the variables. Unit root tests are important in examining the stationarity of a time series because nonstationary regressors invalidates many standard empirical results and thus requires special treatment. Granger and Newbold (1974) have found by simulation that the F-statistic calculated from the regression involving the nonstationary time-series data does not follow the Standard distribution. This nonstandard distribution has a substantial rightward shift under the null hypothesis of no causality.

Thus the significance of the test is overstated and a spurious result is obtained. The presence of a stochastic trend is determined by testing the presence of unit roots in time series data. Non-stationarity or the presence of a unit root can be tested using the Dickey and Fuller (1981) tests.

The test is the t statistic on ϕ in the following regression:

$$\Delta Y_t = \beta_0 + \beta_1.trend + \rho Y_{t-1} + \sum_{i=0}^{\infty} \phi_i \Delta y_{t-i} + \varepsilon_t \quad (5)$$

Where Δ is the first-difference operator, ε_t is a stationary random error (Chang, at all, 2001).

Tests of Cointegration

The cointegration test is based in the methodology developed by Johansen (1991), and Johansen and Juselius (1993). Johansen's method is to test the restrictions imposed by cointegration on the unrestricted variance autoregressive, VAR, involving the series. The mathematical form of a VAR is

$$y_t = \theta_1 y_{t-1} + \dots + \theta_p y_{t-p} + \vartheta X_t + \varepsilon_t \quad (6)$$

where y_t is an n -vector of non-stationary $I(1)$ variables, x_t is a d -vector of deterministic variables, $\theta_1, \dots, \theta_p$ and ϑ are matrices of coefficients to be estimated, and ε_t is a vector of innovations that

may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and other right-hand side variables. We can rewrite the VAR as (Eq. (7)):

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=0}^{\infty} \Gamma_i \Delta y_{t-i} + \beta_{xt} + u_t \tag{7}$$

Where (Eq. (8))

$$\Pi = \sum A_i - I_t \quad \text{that} \quad \Gamma_i = -\sum A_j \tag{8}$$

Granger’s representation theorem asserts that if the coefficient matrix n has reduced rank $r < n$, then there exist $n \times r$ matrices α and β each with rank r such that $\pi = \alpha \beta'$ and $\beta' y_t$ is stationary. Here, r is the number of cointegrating relations and each column of β is a cointegrating vector. For n endogenous non-stationary variables, there can be from (0) to $(n-1)$ linearly independent, cointegrating relations (Yin and Xu, 2003; Aktaş, Cengiz and Yılmaz, Veysel, 2008).

DATA AND EMPERICAL RESULTS

Data

The data used in this study consist of annual time series of GDP and oil consumption for Iran 1980 to 2010. Annual time series data were utilized in this study. The series for Iran cover the period 1980-2010; the data are obtained from *BP Statistical Review 2011* and the *Titi Tudorancea Bulletin*.

GDP: Gross Domestic Product (1.000.000\$),

OIL: Oil Consumption (Thousand Barrels Per Day).

Figure 1 and 2, respectively, describes oil consumption and GDP over the period of 1980-2010.

RESULT OF UNIT ROOTS AND COINTEGRATION TEST

The results of the unit root tests for the series of Oil consumption and GDP variables are shown in Table 1. The ADF test provides the formal test for unit roots in this study. The p-values corresponding to the ADF values calculated for the two series are larger than 0.05. This indicates that the series of all the variables are non-stationary at 5% level of significance and thus any causal inferences from the two series in levels are invalid.

Table-1. Results of ADF Test for Unit Roots

Variables	Trend and Intercept	first difference	Critical values (5%)	
LOILCON	-2.51	-5.72	-3.63	-3.64
LGDP	-1.97	-4.27	-3.57	-3.58

Note: The optimal lags for the ADF tests were selected based on optimising Akaike’s information Criteria AIC, using a range of lags. We use the Eviews soft ware to estimate this value.

Source: BP Statistical Review 2011 and the Titi Tudorancea Bulletin.

The analysis of the first differenced variables shows that the ADF test statistics for all the variables are less than the critical values at 5% levels (Table 1). The results show that all the variables are stationary after differencing once, suggesting that all the variables are integrated of order I(1).

As indicated, the basic idea behind cointegration is to test whether a linear combination of two individually non-stationary time series is itself stationary. Given that integration of two series is of the same order, it is necessary to test whether the two series are cointegrated over the sample period. The results of the Johansen cointegration test for the series OILCON and GDP are reported in Table 2.

Table-2. Results of Johansen's Cointegration Test

Null Hypotheses	Alternative Hypotheses	Trace Statistic	Critical Value (5%)
H0	H1		
$r=0$	$r=1$	9.40	15.49
$r \leq 1$	$r=2$	3.58	3.84

Source: BP Statistical Review 2011 and the Titi Tudorancea Bulletin, we use the Eviews soft ware to estimate this value.

The likelihood ratio tests show that the null hypothesis of absence of cointegrating relation ($r = 0$) cannot be rejected at 5% level of significance. Thus, we can conclude that oil consumption and GDP are not cointegrated in the long run.

RESULTS OF ERROR-CORRECTION MODEL

If the series of two variables are non-stationary and the linear combination of these two variables is stationary, then the error correction modeling rather than the standard Granger causality test should be employed. Therefore, an ECM was set up to investigate both short-run and long-run causality. In the ECM, first difference of each endogenous variable (GDP and OILCON) was regressed on a period lag of the cointegrating equation and lagged first differences of all the endogenous variables in the system, as shown in Eq. (3). The results of error correction model are presented in Table 4.

Table-3. The Result of Error Correction Model

	Lag Lengths		F Statistics	t statistics for ECMt-1
$\Delta \text{GDP} - \Delta \text{OIL}$	m=2	n = 2	4.74	-2.90*
$\Delta \text{OIL} - \Delta \text{GDP}$	m=1	n = 1	1.43	1.36*

Notes: The lag lengths are chosen by using AIC information criterion. * Denotes the rejection of the null hypothesis at 5% level of significance.

According to results of the Table 3, short-run causality is found to run from economic growth to oil consumption. That is, there is directional short-run Granger-causality economic growth to oil consumption. The coefficient of the ECM is not be significant in Eq. (3) and (4), which indicates that no exists bidirectional Granger causality between oil consumption and economic growth in long run. In other words, if unidirectional causality runs from energy consumption to income, reducing energy consumption could lead to a fall in economic growth.

CONCLUSION

This paper has investigated the ECM model to examine the causal relationship between oil consumption and GDP in Iran using the annual data covering the period of 1980- 2010. Prior to testing for causality, the ADF test and Johansen maximum likelihood test were used to examine for unit roots and cointegration. Our estimation results indicate in short run that there are bidirectional short-run causality between economic growth and oil consumption.

Results verify that both direct and indirect Granger causality does not show a long run effect of oil consumption on economic growth. That is, our research reveals that energy consumption does not lead to economic growth and hence substantial energy consumption is not likely to bring about significant economic growth but an increase in pollution. It is very important for this country adopt appropriate energy policy in order to promote economic growth. Since Iran has a high oil exports, efficient use of oil and substituting of gas and technology for oil could be good policy measures.

REFERENCES

- Abosedra, S., Baghestani, H. (1989)** “New evidence on the causal relationship between US energy consumption and gross national product”. *Journal of Energy Development*, Vol. 14, pp. 285-292.
- Akarca, A.T. and Long, T.V. (1980)** “On the relationship between energy and GDP: a reexamination”, *Journal of Energy Dev*, Vol. 5, pp. 326-331.
- Aktaş, Cengiz and Yilmaz, Veysel. (2008)** “Causal relationship between oil consumption and economic growth in Turkey”, *Kocaeli Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, Vol. 15, pp. 45-55.
- Asafu-Adjaye, J. (2000)** “The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries”, *Energy Economics*, Vol. 22, pp. 615-625.
- BP Statistical Review of World Energy (2011)** www.bp.com/centres/energy/index.asp.
- Cheng, B. (1995)** “An investigation of cointegration and causality between energy consumption and economic growth”, *Journal of Energy Development*, Vol. 21, pp. 73-84.
- Chang, T. Fang, W and Wen, L.F. (2001)** “Energy consumption, employment, output, and temporal causality: evidence from Taiwan based on cointegration and error-correction modelling techniques”, *Applied Economics*, Vol. 33, pp. 1045-1056.
- Dickey, D.A. and Fuller, W.A. (1981)** “Likelihood ratio statistics for autoregressive time series with a unit root”, *Econometrica*, Vol. 49, pp. 1057-1072.
- Engle, R.E., Granger, C.W.J. (1981)** “Cointegration and error-correction: representation, estimation and testing”, *Econometrica*, Vol. 55, pp. 251-276.
- Erol, U. and Yu, E.S.H. (1987a)** “Time series analysis of the causal relationships between US energy and employment”, *Resources Energy*, Vol. 9, pp. 75-89.

Glasure, Y.U., Lee, A.R. (1997) “Cointegration, error-correction, and the relationship between GDP and energy: the case of South Korea and Singapore”, *Resource and Energy Economics*, Vol. 20, pp. 17-25.

Granger, C. and Newbold, P. (1974) “Spurious regressions in econometrics”, *J. Econometrics*, Vol. 2, pp. 111-120.

<http://www.titudorancea.com>.

Johansen, S., Juselius, K. (1990) “Maximum likelihood estimation and inferences on cointegration with approach”, *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-209.

Johansen, S. (1988) “Statistical analysis of cointegrating vectors”, *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231-254.

Kraft, J. and Kraft, A. (1978) “On the relationship between energy and GDP”, *Journal of Energy Development*. Vol. 3, pp. 401-403.

Mackinnon, J. (1991) “Critical values for cointegration tests, long run economic relationships reading, in *Cointegration*”, Oxford University Press, New York, 267- 76.

Masih, A.M.M., Masih, R. (1998) “A multivariate cointegrated modeling approach in testing temporal causality between energy consumption, real income and prices with an application to two Asian LDCs”, *Applied Economics*, Vol. 30, pp. 1287-1298.

Nelson, C. R. and Plosser, C. I. (1982) “Trends and random walks in macroeconomic time series some evidence and implications”, *Journal of Monetary Economics*, Vol. 10, pp. 139- 162.

Odhiambo. M. N., 2010. Oil prices and economic growth in South Africa: an ARDL testing approach.

Pesaran, M., Pesaran, B. (1997) “Working with microfit 4.0: interactive economic analysis”, Oxford University Press, Oxford.

Pesaran, M., Shin, Y. (1999) “An autoregressive distributed lag modeling approach to cointegration analysis” in S. Strom, (ed) *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch centennial Symposium*, Cambridge University Press, Cambridge.

Pesaran, M., Shin, Y., Smith, R. (2001) “Bounds testing approaches to the analysis of level relationships”, *Journal of Applied Econometrics*, Vol. 16, pp. 289-326.

Sargan JD. (1964) “Wages and prices in the United Kingdom: A study in econometric methodology”, In *Econometric Analysis for National Economic Planning*, Hart PE, Mills G, Whitaker JK (eds). Butterworth and Co.: London (1964); pp. 25–54.

Sims, C.A. (1972) “Money, income and causality”, *American Economic Review*, Vol. 62, pp. 540-552.

Solow R. M. (1978) “Resources and economic growth”, *American Economist*, Vol. 22, pp. 5-11.

Fig-1. Oil Consumption in Iran

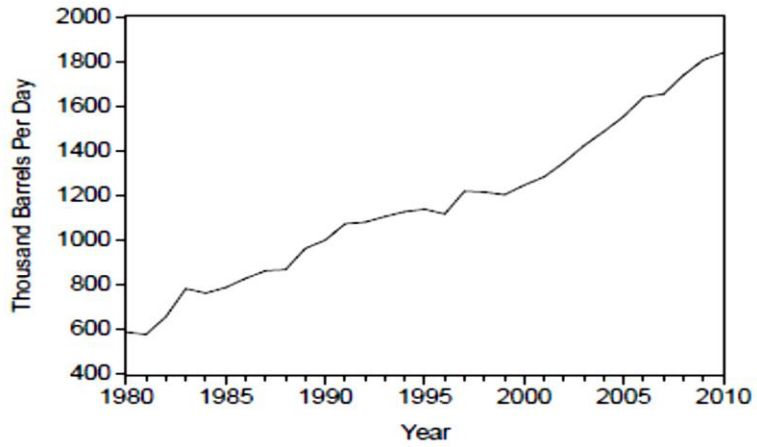


Fig-2. GDP in Iran

