Energy conservation: an alternative for investment in the oil sector for OPEC Member Countries

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Abstract

Investment in the oil sector is the main policy of expanding net crude oil export capacity in OPEC Member Countries. The other alternative should be improving energy conservation policies. Since these countries benefit from cheap energy sources, it is reasonable to expect inefficient use of energy in their economies, resulting in relatively high energy intensity. This paper deals with the causality relationship between energy consumption and gross domestic product (GDP). First, stationary tests are run. Second, if there is a cointegrating relationship, an error correction model is applied; otherwise a standard Granger causality test is conducted. It was discovered that for all OPEC Member Countries we cannot statistically accept causality running from energy to GDP. Therefore, not only are proper conservation policies not a threat to economic growth, they also lead to an expansion of oil export capacity.

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THE CAUSAL RELATIONSHIP between energy consumption and gross domestic product (GDP) is a well-known topic in the literature of energy economics in the context of Granger causality (Granger, 1969). The direction of causality has significant policy implications, especially in energy conservation. If energy consumption does not cause GDP, conservation policies can be applied without any adverse effect on economic growth, thereby increasing export potential.

Empirically, attempts have been made to find the direction of causality between energy consumption and economic activity. The pioneer study by Kraft and Kraft (1978) found unidirectional causality running from gross national product (GNP) to energy consumption for the United States. Yu and Choi (1985) also found causality from energy to GDP in the Philippines, but it was reversed in the case of the Republic of Korea. Erol and Yu (1987) tested data for six industrialised countries and found no significant causal relationship between energy consumption, GDP growth and employment. The empirical evidence by Hondroyiannis (2002) suggests that there is a long-run relationship between energy consumption and GDP for the case of Greece. The empirical results by Wankeun Oh and Kihoon Lee (2004) for the case of Korea suggest the existence of a long-run bidirectional causal relationship between energy and GDP, and a short-run unidirectional causality running from energy to GDP.

This paper investigates the causal relationship between energy consumption and GDP for OPEC Member Countries (MCs) for the period 1970–2001. For this propose, first the stationary test is examined for all series. Second, the cointegration test is run for integrated series in the same degree. Third, the standard Granger causality and vector error correction model (VECM) is run.

1. Energy consumption in OPEC Member Countries

A common characteristic of OPEC MCs is their dependency on oil-export revenues. Maintaining or increasing oil export capacity needs the implementation of policies such as investment in the oil sector, fuel substitution and energy conservation. Rich energy resources, along with policies emphasising socio-economic development, such as fuel subsidy policies, are the major reasons to expect inefficient use of energy in OPEC MCs. Therefore, it is reasonable to expect energy intensity to be high. **Table 1** shows the energy intensity for these countries and also for the world, China and India in 1971 and 2001. The indices are defined as ratios of total primary energy consumption to real GDP. Because of fuel substitution and structural changes, energy consumption, rather than oil consumption, has been taken into consideration for deriving intensity. On the other hand, inefficient use of total energy results from inefficient use of oil consumption, as it accounts for a large share of total energy consumption. Except for Indonesia, the indices show an upward movement in comparison with others benefiting from declining trends. This indicates an increasing inefficient use of energy for those countries. Indonesia has succeeded in reducing the index, but the possibility of this trend continuing must be examined. Thus, energy conservation policies probably should be considered as a useful means of reducing domestic consumption. This, in turn, can be an attractive means of increasing export potential.

Table 1
Energy intensity index

	1971	2001
Algeria	0.24	0.59
Indonesia	0.97	0.7
IR Iran	0.42	1.0
Kuwait	0.2	0.6
SPLAJ	0.3	0.5
Nigeria	2.3	2.9
Qatar	0.2	1.2
Saudi Arabia	0.13	0.8
UAE	0.14	0.64
Venezuela	0.4	0.7
India	1.55	1.08
China	3.3	0.9
World	**0.38**	**0.3**

Source: Energy balances of non-OECD countries, OECD/IEA.

2. Methodology

The standard Granger (1969) test is a traditional technique for testing causality between variables. With regard to the equations 1 and 2, if past values of a variable y significantly contribute to forecast the value of another variable x_{t-1} then y is said to Granger cause x and *vice versa*.

$$y_t = a + \sum_{k=1}^{m} \beta_{1k} y_{t-k} + \sum_{j=1}^{n} \alpha_{1j} x_{t-j} + u_t \tag{1}$$

$$x_t = b + \sum_{k=1}^{m} \beta_{2k} y_{t-k} + \sum_{j=1}^{n} \alpha_{2j} x_{t-j} + v_t \tag{2}$$

where y and x are the variables to be tested, u_t and v_t are mutually uncorrelated white noise errors, t denotes the time period and ‘k’ and ‘j’ are numbers of lags.

Recent developments in the time series analysis have suggested some improvements in the standard Granger test. The first step is to check for the stationary of the original variables and, second, testing cointegration between variables integrated in the same order.

The augmented Dickey-Fuller (ADF) (1979) and Phillips Perron (PP) (1988) tests are applied for examining unit roots and stationary. The general model includes both the constant and the trend:

$$\Delta Y_t = \gamma + \delta t + \alpha Y_{t-1} + \theta_j \sum_{j=1}^{n} \Delta Y_{t-j} + e_t \quad (3)$$

where Y_t is the variable under consideration i.e. the natural logarithm of real GDP or energy consumption, Δ represents the first-difference operator, t represents a time trend and e_t is the random error term. Akaike's Information Criterion (AIC) is used for choosing the optimal lag length. The null hypothesis H_0, that $\alpha = 0$ (i.e. Y_t is not stationary) is tested against H_1, that $\alpha \neq 0$ (Y_t is stationary).

When both series are integrated of the same order, it is allowed to test for the presence of cointegration. The Johansen (1988) and Johansen and Juselius (1990) maximum likelihood procedure is used for this purpose. The test considers a VAR of order p:

$$Y_t = A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + \varepsilon_t \quad (4)$$

It can be rewritten as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t, \quad (5)$$

where

$$\Pi = \sum_{i=1}^{p} A_i - I \text{ and } \Gamma_i = -\sum_{j=i+1}^{p} A_j$$

The coefficient matrix $\prod$ is estimated unrestricted, followed by the testing of the restrictions implied by the reduced rank of $\prod$.

The existence of a cointegration relationship indicates that there are long-run relationships among the variables; therefore, there is at least a bidirectional relation among the variables. Engle and Granger (1987) utilised the error correction model (ECM) to determine the direction of causality. The ECM is used to examine the direction of causality between real GDP and energy consumption and to distinguish between short-run and long-run causality.

The ECM model formulates as follows:

$$\Delta Y_t = \alpha_1 + \alpha_y \mu_{t-1} + \sum_{i=1} \alpha_{11i} \Delta Y_{t-i} + \sum_{i=1} \alpha_{12i} \Delta X_{t-i} + \varepsilon_{yt} \quad (6)$$

$$\Delta X_t = \alpha_2 + \alpha_x \mu_{t-1} + \sum_{i=1} \alpha_{21i} \Delta Y_{t-i} + \sum_{i=1} \alpha_{22i} \Delta X_{t-i} + \varepsilon_{xt} \quad (7)$$

where Y_t and X_t represent natural logarithms of real GDP and energy consumption, respectively and (ΔY_t, ΔX_t) are the differences in these variables which capture their short-run disturbances. ε_{yt}, ε_{xt} are the serially uncorrelated error terms and μ_{t-1} is the lagged error correction term, which is derived from the long-run cointegration relationship and measures the magnitude of past disequilibrium.

3. Empirical results

In this study, the time series data of real GDP (LG) and total primary energy consumption (LE) in logarithm for the 1970–2001 period for OPEC MCs, excluding Iraq, have been used.

ADF and PP tests have been run to determine the integration properties of the series for all countries. With regard to the results, countries are categorised in two groups according to the stationary or non-stationary properties of both the GDP and energy consumption series in levels, or the first difference.

Group one contains those for which both series, or at least one of them, is I(0). Algeria, the Socialist People's Libyan Arab Jamahiriya (SPLAJ), Kuwait, Venezuela, the United Arab Emirates (UAE) and Saudi Arabia rank in this group. Group two contains those for which both series are stationary in the first difference. They include Nigeria, the Islamic Republic of Iran, Qatar and Indonesia. The standard Granger causality has been used for group one, in order to test for causality. **Table 2** shows the outcome. Results for all countries reject the premise that energy consumption Granger causes GDP.

Table 2
Standard Granger causality tests

	Direction of causality	F	Probability
Algeria	LG does not Granger cause LE	9.6*	0.00034
	LE does not Granger cause LG	1.3	0.29
Kuwait	LG does not Granger cause LE	4.3*	0.05
	LE does not Granger cause LG	0.3	0.60
SPLAJ	LG does not Granger cause LE	1.3	0.27
	LE does not Granger cause LG	1.4	0.25
Saudi Arabia	LG does not Granger cause LE	7.9*	0.008
	LE does not Granger cause LG	0.1	0.71
UAE	LG does not Granger cause LE	0.7	0.41
	LE does not Granger cause LG	0.4	0.51
Venezuela	LG does not Granger cause LE	5.1*	0.008
	LE does not Granger cause LG	0.07	0.97

*Notes: * null hypothesis rejected.*

For group two, given that integration of the two series is of the same order, we could continue to test whether the two series cointegrated over the sample period. For this purpose, a cointegration test, based on Juselius and Johanson, has been applied.

Evidence shows the existence of a cointegration relationship, which indicates that there is a long-run relationship among the variables for all countries. To determine the direction of causality between real GDP and consumption, the VECM is used. T**able 3** shows the final results. It is evident that energy consumption does not cause GDP growth in all cases in the short term, as well as in the long term.

Table 3
Causality results based on VECM

	Direction of causality	Short term	Long term
Indonesia	LG does not cause LE	not reject	reject*
	LE does not cause LG	not reject	not reject
IR Iran	LG does not cause LE	reject	reject*
	LE does not cause LG	not reject	not reject
Nigeria	LG does not cause LE	not reject	reject
	LE does not cause LG	not reject	not reject
Qatar	LG does not cause LE	not reject	not reject
	LE does not cause LG	not reject	not reject

4. Conclusions

This paper has attempted to find the causal relationship between energy consumption and GDP using standard Granger causality and the VECM model in OPEC MCs. Countries were categorised in two groups according to the stationary tests. Standard Granger causality was run for Algeria, SPLAJ, Kuwait, Venezuela, the UAE and Saudi Arabia, and the VECM was established for Nigeria, IR Iran, Qatar and Indonesia.

The empirical results indicate that there is not any relationship running from energy consumption to GDP in both the short run and long run for all countries. This argument has important policy implications through which energy conservation is not threatening to hurt economic growth. Therefore, a reduction in domestic energy consumption through conservation policies leads to the expansion of export capacity. It is suggested that the next research on this subject should concentrate on the evaluation of conservation capacity and policies to implement such plans.

References

Anjum, A., and B.S. Butt (2001), ''The relationship between energy consumption and economic growth in Pakistan", Asia-Pacific Development Journal, Vol. 8, No. 2, 101–10.

Dickey, D., and W. Fuller (1979), "Distribution of the estimators for autoregressive time series with a unit root", Journal of the American Statistical Association, 74 (366), 427–31.

Enders, W. (1995), "Applied Econometric Time Series", Wiley, New York.

Erol, U., and E.S.H. Yu (1987), "On the relationship between energy and income for industrialised counties", Journal of Energy and Employment, 13, 113–22.

Greene, W.H. (1993), "Econometric Analysis", Macmillan, New York.

Gurer, N., and J. Ban (2000), "The economic cost of low domestic product prices in OPEC Members Countries", OPEC Review, Vol. XXIV, No. 2, 143–64.

Hondroyiannis, G., S. Lolos, and E. Papapetrou (2002), "Energy consumption and economic growth: assessing the evidence from Greece", Energy Journal, 24, 319–36.

Johansen, S., and K. Juselius (1990), "Maximum likelihood estimation and inference on cointegration — with applications to the demand for money", Oxford Bulletin of Economics and Statistics, 52 (2).

Kraft, J., and A. Kraft (1978), "On the relationship between energy and gross national product (GNP)", Energy Development, 3, 401–03.

Oh, W., and K. Lee (2004), "Causal relationship between energy consumption and gross domestic product revisited the case of Korea 1970–99", Energy Economics, 26, 51–59.

Phillips, P.C.B., and P. Perron (1988), "Testing for unit root in time series regression", Biometrica.75, 335–46.

Yu, S.H., and J.Y. Choi (1985), "The causal relationship between energy and GNP: an international comparison", Journal of Energy Development 10, 249–72.

